Washington
Internships for
Students of
Engineering

TRANSBUS AND THE ADVANCED DESIGN BUS:

THE STRUGGLE FOR AN INNOVATIVE BUS

by

Adlynn Kustin[1]

May 1988

Prepared as part of the 1983 Washington Internships for Students of Engineering (WISE) Program under the supervision of Dr. Barry Hyman[2], 1983 WISE Faculty-Member-in-Residence. Modified and edited by Dr. Hyman. All opinions presented are those of the author and do not in any way represent those of the author's institution, or of other individuals or institutions referred to in the text.

---

[1] Mechanical Engineering Student, Columbia University. Ms. Kustin's participation in WISE was sponsored by the American Society of Mechanical Engineers.

[2] Associate Professor, Mechanical Engineering and Public Affairs, University of Washington.

A study of the efforts of the Department of Transportation and the bus manufacturing industry to produce an innovative bus in the 1970s. The technical issues are examined along with the associated policy issues and controversies.

TABLE OF CONTENTS

INTRODUCTION

In 1964 Congress passed the Urban Mass Transportation Act and the federal government became involved in developing urban transportation systems. The Act was the beginning of what would be a long and difficult struggle to upgrade public transportation in the United States.

A study conducted by the National Academy of Engineering in 1968 concluded that a new generation urban bus design was needed to replace the "New Look" design in use since 1959. Among the goals to be met by the innovative bus were: a lower floor for improved access by the elderly and the handicapped; a more comfortable ride; energy conservation; and easier maintainability.

In 1970, the Urban Mass Transportation Administration (UMTA) of the United States Department of Transportation (DOT) announced its "Transbus" program. UMTA contracted with the consulting firm Booz-Allen Applied Research in 1971 to help develop the government funded prototypes. The "object (was) to produce (a) modern, comfortable, reliable standardized 40 foot bus."[1] The government vs. manufacturers battle was about to begin.

---

[1] "Oversight of the Urban Mass Transportation Administration's Technology Development and Equipment Procurement Programs (Bus and Rail Rolling Stock)," Hearings Before the Subcommittee on Oversight and Review of the Committee on Public Works and Transportation, U.S. House of Representatives, Ninety-Sixth Congress, first session, May 16, 17, 22, 1979 (Washington: U.S. Government Printing Office, 1979), p.3.

PART A: IMPLEMENTATION OF A NEW DESIGN

1971-1973: Prototype Development

In 1971, Mike Buckel joined Booz-Allen as a test engineer and began work on the Transbus project. Mike had received a B.S. in Mechanical Engineering from Washington University in St. Louis and a Master of Automotive Engineering from Chrysler. He worked at Chrysler for nine years before joining Booz Allen. During the next three years, Mr. Buckel would become involved in developing what was to be the "next generation of transit buses." According to the Urban Mass Transportation Administration's (UMTA) proposal, each of three manufacturers (AM General, General Motors Corporation, Rohr Flxible) were to produce three prototypes. Those designs would be tested and the design of a production bus would combine the best features of the prototypes. The schedule was laid down by UMTA. The proposals from the manufacturers would be accepted at the end of 1971, contracts would be granted in January of 1972 and, as Mike Buckel put it, the prototypes would be "running in time for the 1972 elections (if you can believe a schedule like that)." As Mr. Buckel expected, the schedule was not followed. It was not until June of 1972 that UMTA approved the contracts for prototype development.

Mike was enthusiastic about the project, calling it a "once in a lifetime opportunity" for an engineer because it was "perceived to have unlimited funding."

At the same time that work began on a Transbus design, General motors had an "advanced design" that they had been working on since the mid 1960s. In 1971, GM wrote to DOT Secretary Volpe explaining that they had already begun work on an innovative design which met the goals of the Academy's study, but they would stop all work on the new bus because of the Transbus project.

The manufacturers were each awarded $8 million and the Transbus prototypes were developed. According to Mike, they were developing "new suspensions and bodies, rearranging drive lines. . . all the things that normally take 15-20 years." Testing was begun on the prototypes in mid 1973. Exhibit A-1 shows photographs of the three prototypes.

1973-1975: Testing the Prototypes

Mike Buckel was the Testing Manager for Transbus. The prototypes underwent performance, safety and then durability tests. During the performance testing, Mike Buckel found that "every part on every bus was unique. . . each bus had a unique set of problems."

For example, the AM General bus had transmission trouble and Mike heard the disc brakes from "a half mile away (and the)

longer you ran them, the hotter they got until there was a white cloud following the thing down the street as the linings were burning up."

"The Rohr bus had four axles--each of the twelve tires pointed in a different direction. The brakes worked real well, but those little tires would overheat, blow up, and shed their tread as even the tires were experimental." Exhibit A-2 shows the rear tandem axle to which Mr. Buckel referred.

Of course the General Motors bus had its problems also. Mike noted that "GM had oil cooled disc brakes which we (Booz-Allen engineers) couldn't get the friction material out of. The friction material from a failed brake would get carried by the oil through the coolers and get distributed throughout the other brake units and would cause them to fail. It would take a week to flush the contaminants out of the brake system."

As part of the in-service demonstration, Mike and others from Booz-Allen took the prototypes out on a cross-country trip. Mike had many discussions with Booz-Allen administrators about the nature of this United States "testing tour." A conversation might have gone something like:

Mike: "We bought a truck and filled it with tools and spare parts."

Booz-Allen: "Whaddya mean 'buy a truck,' what do you mean 'buy tools'? Who's going to drive them?"

Mike: "Mechanics."

Booz-Allen: "We don't hire mechanics, we're scientists."

Mike: "We've got some buses to keep running."

Booz-Allen: "But those buses were built by the three eminent manufacturers in the U.S. What makes you think they're going to break?"

Mike: "Believe me, they're going to break."

Mike kept a map of the trip. He said they "tried to convoy them whenever possible, but the AM General usually died about a day out. Coming from Miami it died in Orlando. Leaving New York it died at the Delaware Water Gap, leaving Kansas City it died at Lemon, Colorado," and they actually had to abandon it "at the bottom of Death Valley and (bring) it out on a hook." Exhibit A-3 is a map indicating the route covered on the trip and the locations of the major breakdowns.

Mike realized that each bus had unique problems because each used a different approach to meetng a given design challenge. Above all, Mike tried to keep in his mind and in UMTA's that

they did not "ever want to confuse those buses with production samples" because the Transbus project was originally "conceived as a prototype development." But that is exactly what did occur as subsequent administrations dubbed the prototypes as THE BUSES. As a result of that judgment, Mr. Buckel saw the problems with Transbus magnified in the public eye. There were four different UMTA administrators during the time when the specifications were being developed, and 18 different individuals responsible for the Transbus contract. In Mr. Buckel's words, there was "a 90 to 180 degree direction change with each administration."

While Mike Buckel and other engineers from Booz-Allen were making their weekly visits to the manufacturers to review the design work they "started seeing things that didn't look right at GM. There weren't enough axles and the floor was too high." GM said they were using their own funds to develop a related design called the RTS-II. Although Mike noted that the RTS-II had "a lot of things that were identical" to Transbus, a government audit found that no government money was being put towards the RTS-II development. GM was bringing the two bus designs along in parallel.

In 1974, Congress attached a stipulation to UMTA's budget for 1975 saying that "none of the funds provided under this Act shall be available... for the purchase of motor buses... unless such . . . buses are designed to meet the mass transportation needs of the elderly and handicapped."[2]

It became that the manufacturers might have their own ideas about innovative bus design to facilitate the elderly and handicapped. The accessibility issue was soon to become a key factor in the impending struggle between the Transbus and the so-called Advanced Design Buses (new designs developed by the manufacturers with "advanced features").

<u>1975-1978: The Advanced Design Conflict</u>

The manufacturers were concerned because "changes in UMTA policy and UMTA Administrators and DOT Secretaries (had) been as regular as the calendar."[3] General Motors and Flxible went ahead with their Advanced Design Buses (ADBs) as "interim buses" to meet the needs of various transit agencies while the Transbus specifications were being worked out. Exhibit A-4 is part of a statement from a DOT lawyer indicating some policy changes at UMTA during 1975 and 1976. "The industry went ahead with advanced design buses on the strength of a decision by . . . UMTA Administrator Patricelli not to mandate Transbus. . . "[4]

---

[2] Oversight and Review Hearings, p.4.

[3] Ibid, p.97.

[4] Ibid, p.128.

Since the Transbus and the ADB were developed at the same time, the designs had many of the same features. But a few key differences are what caused much of the controversy. Exhibit A-5 is a specification and performance comparison of the Transbus and ADB.

The difference in floor height was substantial and caused the greatest uproar. After kneeling -- a process whereby air bags are deflated in the front of the bus so it "kneels" to the curb for easier access -- the Transbus floor height was to be 18 inches, the ADB 24 inches. The difference was due to an extra step on the ADB. Exhibit A-6 shows the entry floor heights for the Transbus in comparison to the ADBs.

Another major difference between the two buses was the dual rear axles in the Transbus (see exhibit A-2). The tandem axle was controversial because it added weight and cost to the bus and in addition required costly and unique tires. The development of various new components was necessitated because of those (and other) distinctions. For example, a smaller diameter tire was needed.

While the technology was still being developed for Transbus, the ADBs went into service. In 1976, Flxible announced that they were going into production of their ADB -- the 870. Exhibit A-7 is an article which appeared in the American Public Transit Association (APTA) magazine Passenger Transport announcing the introduction of the Flxible 870.

At that time, Ed Kravitz was an engineer at Rohr/Flxible in Delaware, Ohio. He had led the engineering group responsible for the design and development of the Transbus and worked to develop the 870 ADB, a project which would bring many disappointments in the coming months.

Also in 1976, the "Houston Consortium," (a group of six transit companies) gave General Motors a large contract for interim (ADB) buses. AM General was angered and sued, saying that the contract was exclusionary since they could not bid on ADBs (they had been working only on Transbus). During the litigation there were no bus orders of any type because UMTA could not determine what was an exclusionary specification. Mr. Kravitz believed that "the specification was in fact exclusionary in that it described the GM RTS-II down to the exact chemistry of the steel in the body! No other manufacturer in the world could have met the specification without starting from scratch with a new design."

Once the ADBs were announced, UMTA decided that it should issue guidelines so that the government would have a definition of ADB procurement. The specification had to be general enough to include both GM's and Flxible's ADBs but exclude the current generation of New Look buses. The result of much work (which Mike Buckel stressed was done after the buses were built) was

the "White Book," (formally, the Department of Transportation's Baseline Advanced Design Transit Coach Specification), a set of guidelines for new 35 ft. and 40 ft. coach designs. It was released on April 4, 1977. Orders were placed and the bus plants reopened. AM General had lost its suit. A year later, it dropped out of the bus business.

Ironically, only one month after the "White Book" was released, U.S. Secretary of Transportation Brock Adams announced a federal mandate that after September 1979, "all buses offered for bid (must) have a floor height of not more than 22 inches capable of kneeling to 18 inches above the ground and to be equipped with a ramp for boarding."[5] In other words, Brock Adams was destroying the ADB procurement process in favor of the Transbus. As Mr. Kravitz put it, "he (Adams) rescinded the Patricelli mandate for a 30-inch floor with 8-inch risers. This action negated eight months of extensive engineering effort to meet the August 1976 Patricelli mandate." Exhibit A-8 shows the public affairs release from the DOT.

During the following two years, much discussion occurred on the controversial Transbus/ADB issue. The bus manufacturers were of course not very happy about having to stop production of their ADBs and restart Transbus.

On April 24, 1978, Thomas Murphy, Chairman of GM spoke out against UMTA's actions, saying that GM's "chief concern over the Transbus (was) that the government intend(ed) it to be the only bus that a region or municipality (could) purchase if they (were) to seek the aid of federal funds."[6]

Similarly, Grumman (who had bought the Flxible Company from Rohr in January) stated that it thought Secretary Adams' mandate was a "questionable action."[7] Mr. Kravitz and other engineers on the bus project at Flxible had already warned the consortium of cities awaiting Transbuses that Flxible "would not be there."

DOT issued the Transbus procurement requirements in August 1978 and amended them one month later. Thus amid the manufacturers' protests, political pressures (the Carter administration was very sensitive to the elderly and handicapped communities) and disagreement between successive DOT and UMTA administrations, tension escalated as the May 2, 1979 bidding deadline approached.

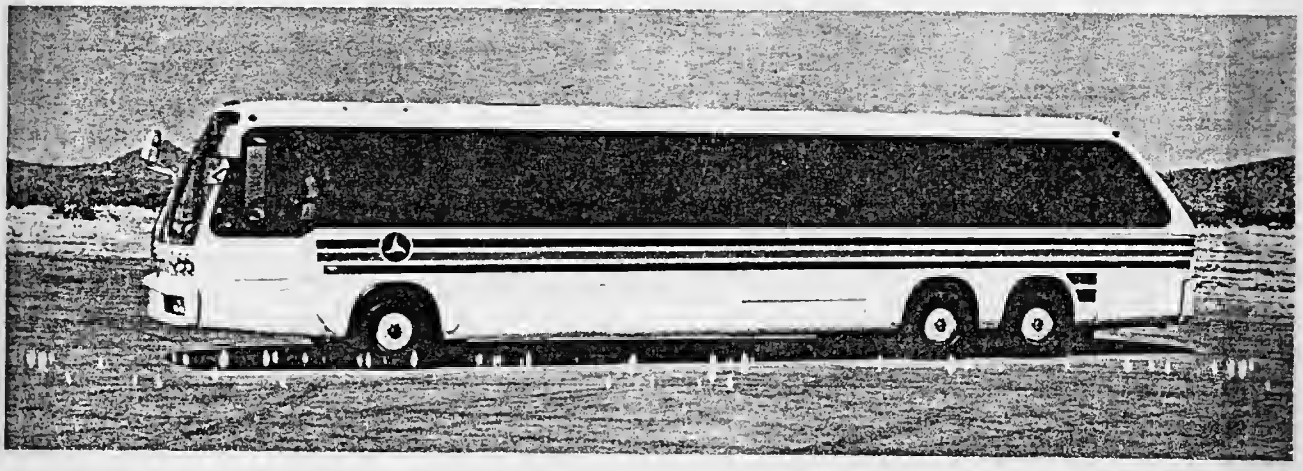
---

[5] Brock Adams, "Department of Transportation News," (May 19, 1977).

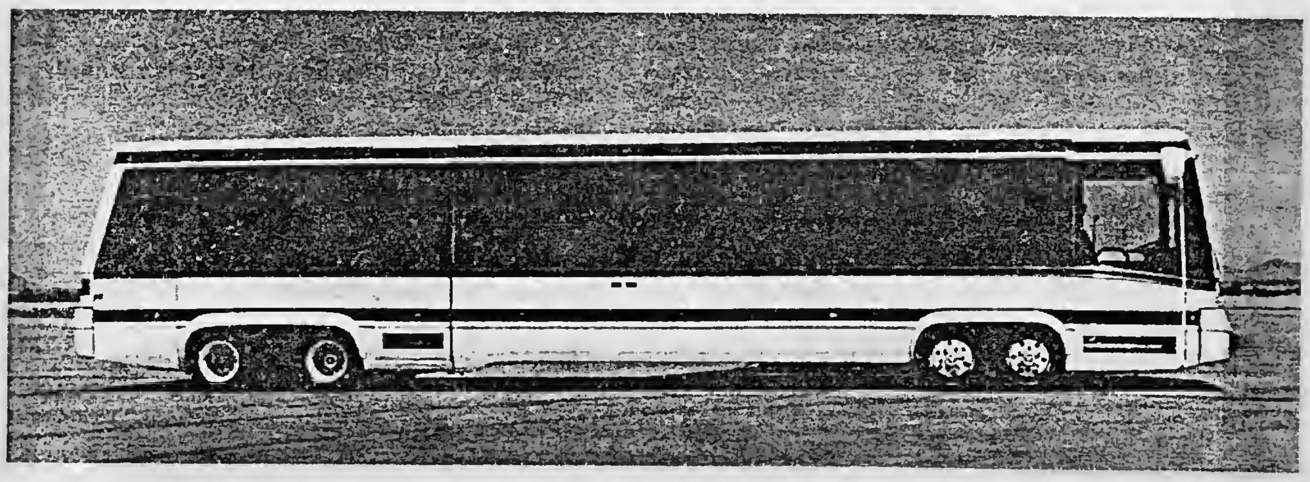
[6] Thomas Murphy, "GMC Transportation Symposium," (April 24, 1978) p.11.

[7] Oversight and Review Hearings, p.128.

AM General Corporation



General Motors Corporation



Rohr Industries

Exhibit A-1 Photos of Transbus Prototypes

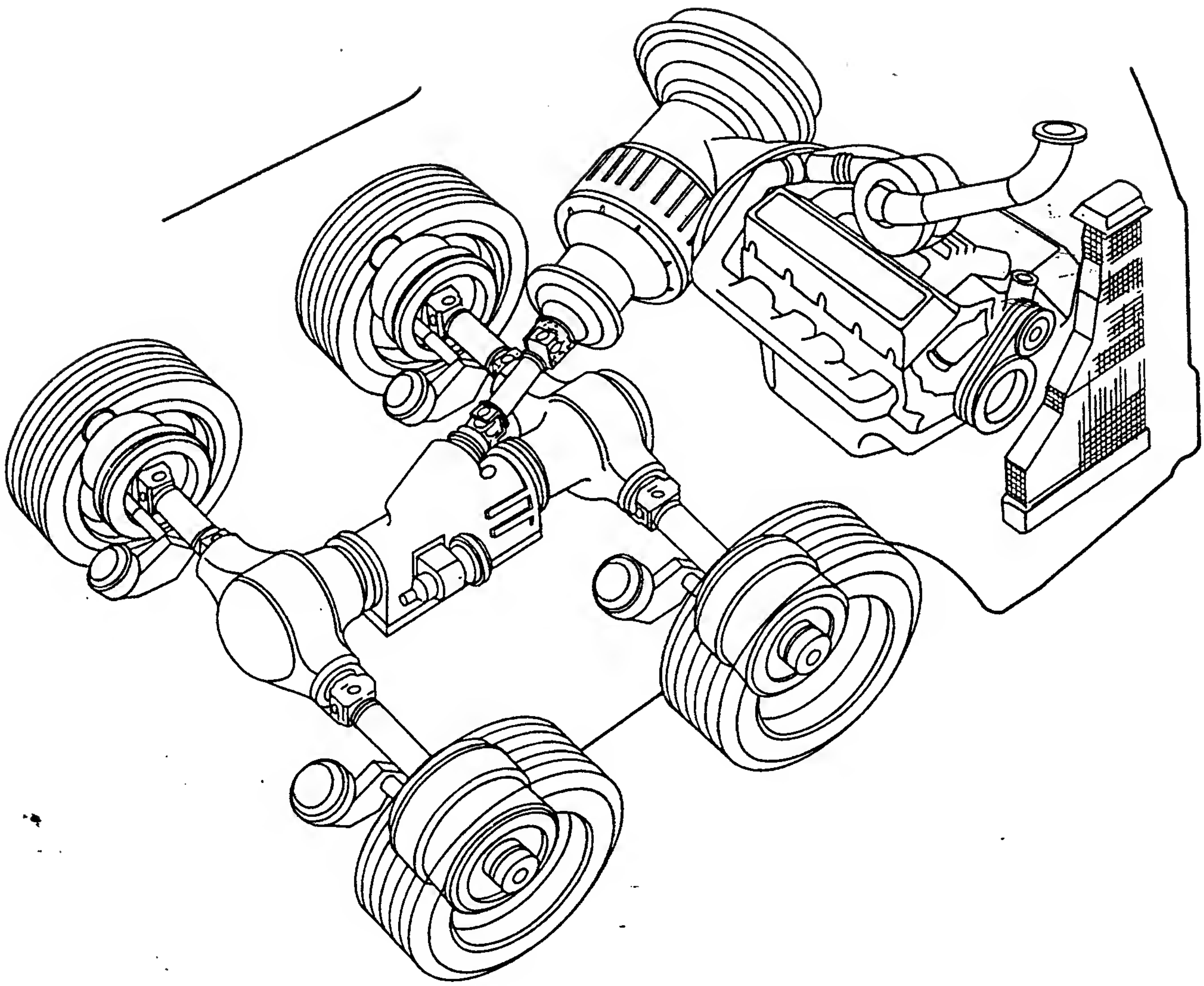
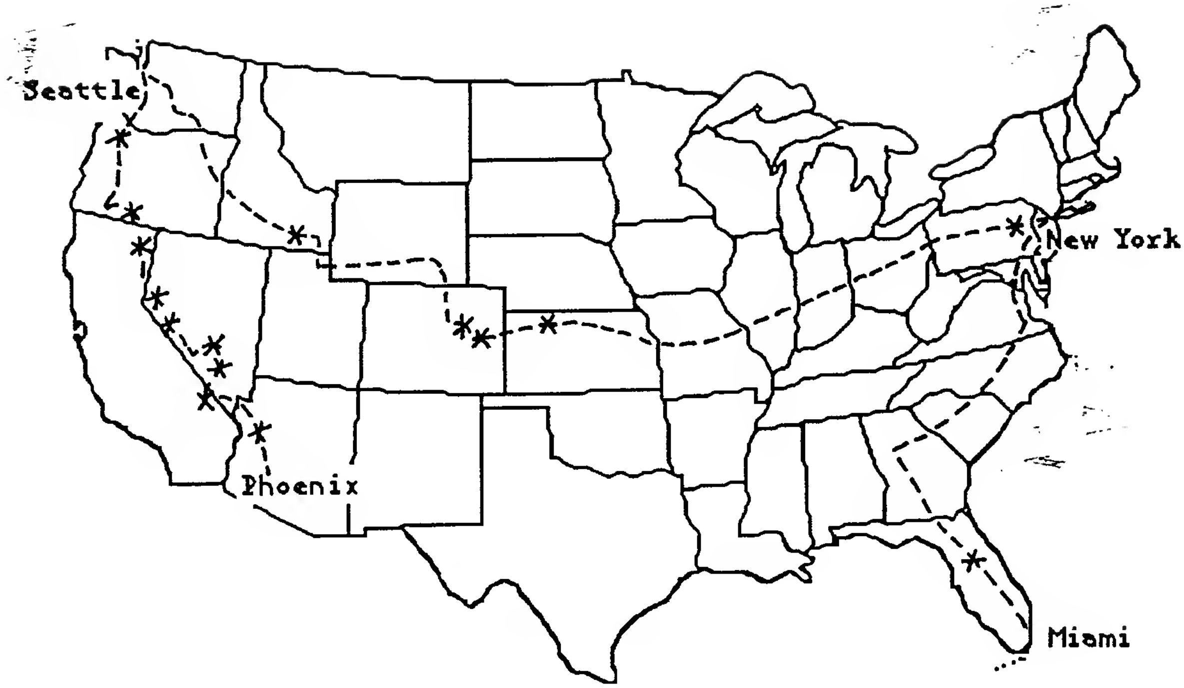


Exhibit A-2 Rear Tandem Axle of the Rohr Flxible Transbus Prototype



"X" denotes a major failure in a prototype

<u>Exhibit A-3</u> Booz-Allen U.S. Tour Map

In January of 1975, UMTA issued a "Policy for Introducing Transbus into Nationwide Service" which announced that UMTA grantees would be required to purchase Transbus and that UMTA would develop a performance specification for the new bus that would be a composite of the prototypes that had been developed by AM General, GM and Flxible. This policy statement did not set a date after which recipients of federal funds would be required to purchase Transbus. However, in recognition of the efforts of General Motors to develop Advanced Design Buses (ADB's) independent of the Transbus program, it did state that in the period prior to introduction of Transbus, UMTA would fund buses such as the ADB's.

Later in 1975, the question of a Transbus mandate had become quite controversial and Robert Patricelli, the new UMTA Administrator, announced that he would reopen the matter. In July 1976, it was announced that Transbus would not be mandated, but that DOT would support procurements of ADB's.

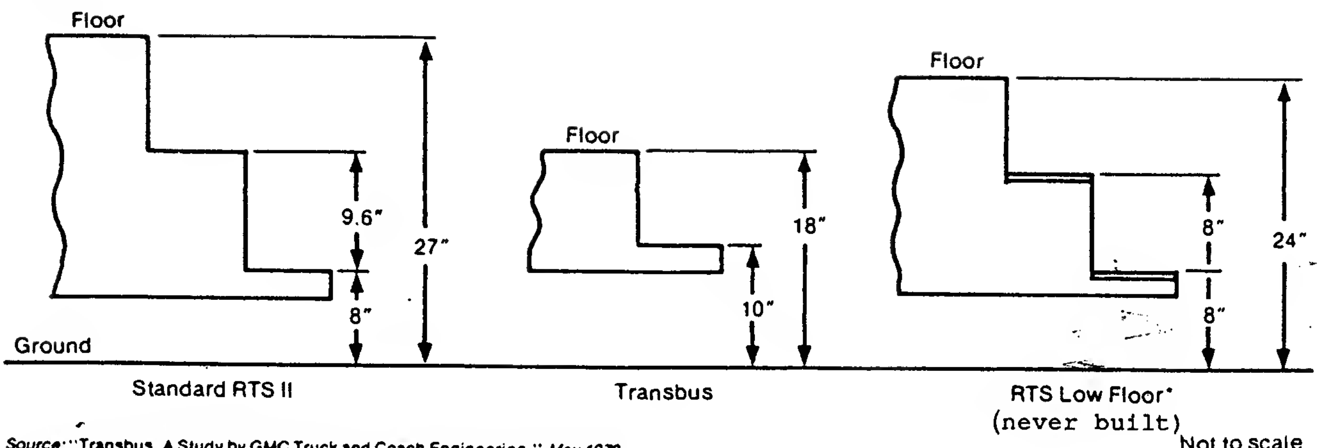
<u>Exhibit A-4</u> Excerpt from Statement by DOT Counsel Kamm

Criterion	ADB	Transbus
Service Life	Twelve years or 500,000 miles	Fifteen years or 600,000 miles
Floor height (before kneeling)	Thirty inches maximum	Twenty-two inches maximum at front door; twenty-four inches maximum at rear door
(After kneeling)	Twenty-four inches maximum	Eighteen inches maximum at front door
Floor Strength	Withstand 150 lbs through a ¼ inch rod	Withstand 150 lbs through a ½ inch rod
Wheel housing material	No specific requirement	Stainless steel
Capacity	Forty-seven seated	Forty-six seated (no wheelchairs)
Front Door Width	Thirty inches minimum	Forty-four inches minimum
Axle Clearance	Six inches minimum	Six and one-half inches minimum
Wheelchair Facilities	Optional	Wheelchair locks and turning room required on each bus
Towing	Towing only from the rear	Towing and lifting from the rear
Curb Visibility	Driver see a six-inch high curb when twelve inches from curb	Driver see a six-inch high curb when six inches from curb
Side Window Material	Acrylic in accord with ANSI Z26.1-1966	In accord with ANSI Z26.1-1977 for AS-3 tempered glass
Seat Fabric Flammability	No requirement	In accord with FAA Regulation 25.853(b)
Fuel Economy	No requirement	3.5 miles per gallon minimum
Passenger Compartment	Twenty feet³ per minimum per passenger	Twenty-five feet³ per minimum per passenger

All other performance parameters are the same for each bus.

Specified Item	Transbus[1]	Flyer	GMCL	GMC RTS-II	GFC 870
A. Technical					
1. Dimensional					
Ground to 1st Step					
- Entrance	14" max	13.5"	13.5"	13.0"	14.0"
- Exit	15" max	14.0"	15.7"	15.7"	15.0"
First to 2nd Step & 2nd to Floor					
- Entrance	8" (1st to floor)	10.7"	10.0"	9.8"	8.0"
- Exit	9½ (1st to floor)	10.7"	9.6"	10.0" est.	10.2"
Floor Height at Front	22" max	34.9"	33.2"	32.0"	30.0"
- Kneeled	18"	30.9"	29.2"	27.0"	24.0"
Door Clearance					
- Entrance	36" min	36.0"	44-48"[2]	30.0"	36.0"
- Exit	24" min	26.5" (push)	26.5" (push)	44.0"	30.0" (push)
Aisle Width	20" min	25.0"	26.0"	22.5"	26.0"
2. Suspension	Automatic Height Control	Air Suspension & Height Control	Air Suspension & Height Control	Air Suspension & Height Control	Air Suspension & Height Control
3. Axle					
- Front	Single	Single, Rockwell Reverse Elliot Type	Single, Rockwell Reverse Elliot Type	Single	Single, Rockwell
- Rear	Tandem	Single, Rockwell 63" Drive Angle	Single, Rockwell 63" Drive Angle	Single, 63" Drive Angle	Single, Rockwell
4. Brakes	Air Actuated	Air Actuated: 14.5"x5" Front 14.5"x10" Rear	Air Actuated: 14.5"x5" Front 14.5"x10" Rear	Air Actuated: 15"x6" Front; 15"x10" Rear	Air Actuated: 14.5"x6" Front; 14.5"x10" Rear
5. Wheels	Compatible with Tires	22.5"x8.25"-10 Stud		22.5"x8.25"	22.5"x8.25"
- Dual Wheel Spacing	Not Applicable	13¼"	13¼"		
6. Tires	Suitable for Conditions	6-11:00x22.5" 43.5" OD&11" Width	6-11.5x20"	6-12.5x22.5	6-11:00x22.5"
7. Engine	DD6V71, 6V71 or Equivalent	DD6V71 Cum. VTB-903	DD6V71/ 6V71	DD6V71/6V71	DD6V71/6V71
8. Transmission	Allison 730 (Automatic)	Allison 730 (Automatic)	Allison 730 (Automatic)	Allison 730 (Automatic)	Allison 730 (Automatic)
9. Electrical System	12 or 24V/ Generator	12V/Alternator	12V/Generator	24-12V/ Generator	12V/Alternator
10. Odometer		Yes	Yes		
11. Body Construction	Durable, Exterior Surface Free of Fasteners	Steel Structure & Aluminum Panels	Monocoque	Unitized Construction	Semi-Monocoque
12. Windows	Fixed	Slides at Side Fixed at Rear	Slides at Side Fixed at Rear	Fixed Acrylic	Fixed Acrylic
14. W/C Lift Available	Yes (or Ramp)	Yes	Yes[2]	Yes (Rear Door)	Yes
B. Operations					
Capacity, Seats	46 min	51 nom.	51 nom.	47	48
Curb Weight, lbs.[3]	25,300 max	22,900[5]	22,000[2]	26,000[4]	24,800[5]
Seated Load Weight, lbs.[3]		30,500	30,000	33,100	32,100
- SLW Front Axle	20,000 max[6]	8,800	8,500	11,900	10,500
- SLW Rear Axle	34,000 max[6]	21,700	21,500	21,200[4]	21,600
Gross Vehicle Weight, lbs.[3] (Number of Passengers)		35,300(80)	34,200 (80)	38,000 (80)	36,800 (80)
Rear Axle (estimated)		23,500	23,700	23,800	24,000

Exhibit A-5 Transbus/ADB Specification Comparison



Source: "Transbus, A Study by GMC Truck and Coach Engineering," *May 1979.*
**These dimensions also apply to the Grumman Flxible 870 with low profile tires.*

Parameter	Transbus	GMC RTS-II Standard	GMC RTS-II Low Floor	Grumman Flxible 870
Front Floor Height	22"	32"	29"	30"
Front Floor Height-Kneeled	18"	27"	24"	24"[1]
Front Steps Number	1	2	2	2
Step Height Nominal	14"	13"	13"	14"
Step Height Kneeled	10"	9.5"	8"	8"[1]
Front Steps Riser Height	8"	9.5"	8"	8"
Rear Door Floor Height	24"	35"	—	35"
Rear Steps Number	1	2	2	2
Rear Steps Riser	9.5"	—	—	10.2"

[1]*With low profile tires, 10 inch with standard 26-inch tires.*

Exhibit A-6 Relative Floor Heights --
ADB vs. Transbus

flxible introduces new transit bus

Officials of Rohr Industries' Flxible Company unveiled July 26, a new 48-passenger interim advanced design urban transit bus. At the same time, company executives called for continued work on the Transbus concept first proposed by UMTA in 1971.

The new model 870 was demonstrated this week to APTA, and the press as well as Congressional staff members and Washington Metropolitan Area Transit Authority personnel. The prototype will go on a 51-city tour during the next four months.

(See Flxible introduces, page 12)

flxible introduces new interim urban transit bus

(From page 1)

Rohr Chairman and Chief Executive Officer Fred W. Garry called the 870 an "interim" vehicle, "but one that directly incorporates many of the innovations developed as a result of experience gained in building three Transbus prototypes.

"Clearly, the Transbus development program . . . will not result in production runs for a period of at least several more years," Garry said. "During that period, we recognize a responsibility to respond with improved technology to the needs expressed by transit properties and their riders."

Flxible Vice-President and General Manager Tom Bernard said the 870 "has been extensively endurance and torture tested on Rohr's private test track at the Riverside Raceway in California in order to assure full compliance with federal design and construction standards."

Bernard added that after some modifications "we will make in the final product, the 870 will be ready for delivery to the transit industry within a year."

The 870 has several special features that will allow increased service for the elderly and handicapped, Bernard said. Standard features include kneeling, which lowers the first step of the bus from 14 inches to nine inches, a 36-inch wide front door to accomodste wheelchairs and a front step de-icer to guarsntee surer footing upon entry.

Bernard also said thst two optionsl features can be installed on the 870. The first, a front door hydraulic lift for wheelchair riders can be fitted for about $7000 according to Bernard.

The other optional feature is a floor grip to fasten wheelchairs to the floor during the ride. Bernard said that most buses would be designed for two wheelchair riders, but could be outfitted for more, although regular seating capacity would be cut.

The new model is 40 feet long and 102 inches wide. Floor height is 29 inches during the kneeling mode. "This is a Transbus from the floor up," Bernard said.

Company engineers told viewers that the 870 had two thirds fewer parts and 75% fewer fasteners than earlier models.

Information released by Flxible states that standsrd models being built now have about 31,000 parts, with 16,000 being fasteners. The 870 will have about 9,000 parts with 4,000 fasteners.

Other design features of the new model include a seamless, one piece roof structure msde of aluminum faced "self-extinguishing urethane." The single piece construction should make the roof leak-proof, officials said.

The route sign on the 870 bus spans 70 inches across the top of the bus, and can be fitted with one foot high letters for the destination.

Garry said that subassembly work on the bus would be done in the firm's plant in Loudonville, Ohio, while final assembly would be completed in Flxible's Delaware shop.

The Rohr chairman told the press that Rohr plsnned to retain the Flxible company, adding that no solid offers to purchase it had been made.

Garry also said that the firm has the plant capacity to produce eight buses a day. Estimates for the cost of a single 870 bus range from $70-75,000 depending on which optional features are ordered.

Company officials hope to receive first ssles orders in the next three months.

<u>Exhibit A-7</u> Passenger Transport Article Announcing Flxible 870 Production - 7/30/76

U.S. Department of Transportation

news:

Office of Public Affairs

Washington D.C. 20590

STATEMENT OF U.S. SECRETARY OF TRANSPORTATION BROCK ADAMS AT PRESS CONFERENCE ON TRANSBUS, THURSDAY, MAY 19, 1977

I am announcing today my decision to require all new public buses purchased with Department of Transportation grants to be designed for easy access by elderly and handicapped persons.

I am directing the use of a new bus specification, requiring all buses offered for bid after September 30, 1979, to have a floor height of not more than 22 inches capable of kneeling to 18 inches above the ground and be equipped with a ramp for boarding.

This decision is based on a public hearing held by this department on March 15 and my review of the information and views submitted by bus manufacturers, groups representing the elderly and handicapped, the American Public Transit Association, and others.

A review of the history of the Transbus program convinces me that simply encouraging Transbus may not result in its introduction now or in the future. Even after this department invested about $27 million in the Transbus program, all serious efforts toward producing Transbus stopped when the Urban Mass Transportation Administration announced in July, 1976, that it would not be mandated.

As most of you are aware, the Transbus program enlisted the aid of the three major domestic bus manufacturers to produce prototype buses that would attract greater ridership, be accessible to all passengers, including the elderly and physically handicapped.

I am aware that many who are opposed to mandating Transbus argue that it is not now within our ability to produce a low-floor, ramped bus which can operate safely and efficiently in day-to-day transit service. These objections are discussed in detail in the decision document and are, in my judgment, satisfactorily refuted.

Additionally, a Transbus mandate does not, in my judgment, interfere with the responsibility of local officials to plan for and implement mass transportation projects. Transbus, in fact, will permit faster and more efficient bus service by minimizing the time required to take on and discharge all passengers, including those who are elderly or handicapped.

I believe it is my responsibility to insure to the extent feasible that no segment of our population is needlessly denied access to public transportation. It is now within our technological capability to insure that elderly and handicapped persons are accorded access to urban mass transit buses. This access is fundamental to the ability of such persons to lead independent and productive lives. We cannot deny them rights that so many others enjoy, when it is within our ability to accord them such rights.

A review of the record convinces me that, at a minimum, the three major domestic bus manufacturers could begin Transbus deliveries within 3-1/2 years. This date allows almost 2-1/2 years for development before bidding would begin, and approximately 15 months thereafter before the buses are actually delivered.

As I said in my opening remarks at the Transbus hearing, we have a very competent bus manufacturing capability in this country as well as abroad, and I believe competition, as well as innovation, must be encouraged. I am certain that these manufacturers can meet the challenge of producing Transbus. Additionally, I believe the pressure of effective competition among the manufacturers will result in a prompt introduction of this needed improvement. If one manufacturer substantially beats the effective date of the mandate, we will consider sole source procurements to get Transbus on the streets as soon as it is available.

Further, I have decided to leave in effect the interim policy on accessibility for the elderly and handicapped. That is, manufacturers must continue to offer optional wheelchair lifts and local transit authorities must either purchase buses with lifts or provide special services for elderly and handicapped passengers.

These decisions and others regarding initial procurements of Transbus and its characteristics are fully discussed in the decision document. That document is now at the printers and will be available early next week. With that background, I would be happy to take your questions.

<u>Exhibit A-8</u> DOT Public Affairs Release

PART B: THE DEBATE

1979: The Confrontation

As early as March 12, 1979, the Grumman Flxible Corporation (GFC) announced its intention not to bid on Transbus. See Exhibit B-1 for the announcement and reasons for Grumman's decision. By that time, Ed Kravitz was the Vice President of Engineering at Flxible and had seen the development of the Transbus and ADB designs. In his eyes (and others' at Grumman Flxible) there were some "technical impossibilities" in the Transbus specifications. Those 14 "impossibilities" are listed in Exhibit B-1. GFC argued that the Flxible ADB 870 actually was a Transbus because it met the goals of the Academy study.

On April 27, 1979, General Motors sent a letter to Transportation Secretary Brock Adams informing him that they would not be bidding on Transbus (see Exhibit B-2). GM noted that their RTS was accessible to the handicapped so that was not the issue -- they were declining to bid because they had concluded that Transbus was a losing business venture.

The May 2 bidding deadline came and went and no bids were received. The DOT was put on the spot because there was a consortium of cities that needed buses and the September deadline for implementation of Secretary Adams' mandate was rapidly approaching.

Hearings were held before the Subcommittee on Oversight and Review of the House Committee on Public Works and Transportation on May 16, 17, and 22. Testimony was provided by spokesmen from GM and GFC, key Department of Transportation personnel, and representatives of the various transit agencies.

Ed Kravitz testified on behalf of GFC. Grumann's stand was made quite clear by statements such as,

> As Transbus specifications evolved and changed, and while UMTA policy evolved and changed, many of the features of Transbus were adopted in the 870 concept development. As a result, the 870 has achieved most of the goals of the Transbus program. In that sense, we believe the original Transbus program is already a success as evidenced by the many features of the ADBs which are a direct outgrowth of the prototype program. We are delivering 870s with wheelchair accessibility. The key difference is eight inches of floor height -- one step.[8]

In defense of their no-bid decision, Mr. Robert Landon, President of Grumman Flxible continued,

[8] Oversight and Review Hearings, p.97.

> Those criticizing us publicly for our no-bid decision have cited the fact that we have already built Transbus prototypes. We must point out that those prototypes were rushed to completion, many components were unique and unproven, and the completed Transbuses were never tested on the real proving ground -- actual revenue service. Furthermore, let me make it clear that the Transbus prototypes had little in common with the present Transbus specifications. The present Transbus concept calls for new design, new tooling and new facilities to manufacture the new bus.[9]

Further, Mr. Landon wondered why no one "seem(ed) willing to recognize"[10] that the 870 is a Transbus. "Is it because private enterprise responded independently? Or is it because the Federal Government just does not want to disengage?"[11]

GM stated similar reasons for not bidding. They claimed that they had tried out a low floor but it had caused problems. Robert Truxell, Vice President and General Manager testified that,

> The RTX (GM's experimental RTS) met or exceeded virtually all of the Academy's criteria. . . Testing of the RTX and its evaluation by transit authorities reveals major engineering and operational difficulties with respect to its low floor. For example, the low floor did not provide adequate ground clearance for the vehicle. It also required unproven, experimental systems and components, such as axles, wheels, tires, brakes and running gear, which meant questionable reliability. There was also a significant weight penalty; anticipated maintenance costs were extremely high; and a greater number of parts -- many of them critical -- was required. In addition, seating capacity was reduced.
>
> Primarily as a result of this adverse reaction to the low floor and subsequent discussions with transit officials, we found it necessary to accept a lesser degree of floor height reduction in the successor to the RTX. The low-floor feature, we concluded -- if at all feasible -- would require a much longer and more intensive research and development period.[12]

In defense of their opposition to Adams' mandate, their statement continued,

> In opposing the Transbus mandate, General Motors did not oppose transit accessibility. In fact, we fully support

[9] Oversight and Review Hearings, p.127.
[10] Ibid., p.127.
[11] Ibid, p.128.
[12] Ibid, p.151.

vehicle accessibility, and have demonstrated this support in our commitment to design and build a reliable lift device on the RTS. . .

We opposed the 1977 mandate for four reasons:

We believed that the low-floor ramp configuration, as mandated had serious drawbacks that would have resulted in less accessibility, not more;

We questioned the stringency of the standards, which set specific design criteria, rather than giving performance-oriented standards;

We believed that the time frame presented in the mandate was insufficient, particularly in light of the time needed to develop and test the many major new components; and

We felt that the DOT's insistence on low-bid procurements under the mandate would preclude introduction of high quality innovations.[13]

Then the Department of Transportation got the chance to give their side of the argument. Linda Kamm, DOT Counsel, stated the DOT was "severely disappointed that no manufacturer chose to submit a bid on the Transbus Consortium procurement." She went ahead to cite some of the reasons that the DOT believed there were no bids. They attributed the lack of bids to the manufacturers' desire to push their ADBs instead of investing money in new technology for Transbus. Exhibit B-3 is an excerpt from Ms. Kamm's testimony expressing those views.

Essentially, what came out of the hearings was that further review was necessary. Exhibit B-4 is the closing statement of the Subcommittee chairman.

In a written statement dated May 30, 1979, UMTA responded to Grumman-Flxible's 14 specification impossibilities (see Exhibit B-5). DOT then sponsored a study of Transbus by the MITRE Corporation. In July 1979, MITRE released its findings that the manufacturers' decisions not to bid were "reasonable, understandable business judgments."[14] A National Research Council Commission on Sociotechnical Systems report later that year supported MITRE's findings.

On August 3, 1979, Acting Secretary Claytor approved a "temporary" delay in the effective date of DOT's Transbus Procurement Requirement. Transbus has not been touched since.

---

[13] Oversight and Review Hearings, p.153.

[14] Transbus: <u>An Overview of Technical, Operational, and Economic Characteristics</u> (Virginia: The Mitre Corporation, 1979), p.ix.

It would appear that the industry had "won" in the final battle over the innovative bus. Both GFC and GM were selling their ADBs, a specification had been issued and it seemed that they were coming out of the struggle looking great. Little did they know what lay ahead.

GRUMMAN FLXIBLE
1660 L STREET, N.W.
SUITE 506
WASHINGTON, D.C. 20036
202-659-5151

March 12, 1979

WHY THE GRUMMAN FLXIBLE CORPORATION HAS DECIDED NOT TO BID FOR THE TRANSBUS PROCUREMENT

Secretary of Transportation Brock Adams has mandated that only a new bus, called "Transbus", would be purchased after a date to be finalized when buses are purchased using federal grant funds. Transbus is a proposed new, low-floor design transit bus which has been perceived to offer some prospect of easier boarding of all passengers, particularly the elderly and the handicapped. Three cities have joined to form a consortium to purchase the first Transbuses, and bids are scheduled to be submitted May 2, 1979.

The Grumman Flxible Corporation (GFC), one of two U.S. suppliers of urban transit buses, has participated in the Transbus program from the outset. GFC has carefully evaluated the present Transbus specifications and solicitation for bid, and has determined that it cannot respond for the following reasons:

1. Transbus is intended to provide more accessibility to public transportation for the elderly and handicapped. As specified for this procurement, Transbus will be no more accessible than the Advance Design Buses now in production. Accessibility is not the issue.

2. The specifications require a commitment to price and manufacture a product that has not yet been designed.

3. GFC does not make all the components of a bus and the companies that supply major components will not commit to develop them under this contract.

4. The proposed Transbus will cost significantly more to buy and to maintain than buses now available. Its procurement would be inflationary and would tend to reduce the total number of transit buses in service.

5. Adequate testing is not provided in this program, which raises important questions of passenger safety.

For further information contact George Prytula--(202)659-5151

TRANSBUS

POSITION OF THE GRUMMAN FLXIBLE CORPORATION

WITH RESPECT TO THE

PENDING INITIAL PROCUREMENT OF TRANSBUSES

MARCH 12, 1979

INTRODUCTION

Since the early 1970's, Grumman Flxible Corporation (GFC) has been involved with and has consistently attempted to cooperate with the Department of Transportation's effort in defining and developing the vehicle known as Transbus.

During the course of that time, GFC has:

(1) been one of the participants in the building of the original Transbus prototypes
(2) testified on at least four different occasions to various governmental and congressional committees regarding our experience and recommendations for Transbus
(3) held repeated meetings with members of UMTA, APTA, the Bus Technology Committee, the Elderly and Handicapped representatives, and the current Consortium, in attempts to achieve a producible, affordable Transbus.

The Grumman Flxible Corporation is now presented with an opportunity to bid firm prices in a very short time on production lots of Transbus. For the past several months, we have been working closely with suppliers and our own engineering staff in a good faith effort to determine whether or not GFC has the technical and financial capability to participate in this program.

The following presentation reflects our findings and conclusions in this matter.

Exhibit B-1 GFC Intention Not to Bid and Reasons for Decline

TECHNICAL RISK

COMMITMENTS BY MAJOR SUPPLIERS

Transbus is a new bus. The bus must be designed in a cooperative effort with suppliers to the extent that firm, fixed price quotations can be obtained. Only the engine and transmission appear to be "knowns" of all the subsystems at this time. This is due primarily to the fact they represent existing components. There is already some question, however, as to whether that power train can meet performance and fuel economy requirements of the Transbus.

All major suppliers contacted to date have uniformly shown great reluctance or outright refusal to bid primarily for:

(1) insufficient engineering detail, and
(2) the extended delivery period

In normal product development, at least 9-12 months are planned at the outset to develop the concept, to establish reasonable feasibility, and to conclude preliminary engineering. It is not possible to do the necessary preliminary engineering in the very few weeks allotted by the current Consortium's advertisement for bid.

Generating engineering detail is not all that is required. Our suppliers point out that new designs must be proven in tests and that these new designs must be paid for. They point out that the limited market for Transbus does not justify investments for major new developments. This brings up the point of federal support of product development. GFC pointed out this need several times in testimony on Transbus. The limited market and unique application call for federal support to maintain even the sole source suppliers in the bus supply business. (See Exhibit "A" for vendors' quotation responses)

SPECIFICATION IMPOSSIBILITIES

The following are 14 of the more onerous issues in the Transbus Technical Specifications. These issues present requirements which are most unusual or are impossible to provide within the framework of the Consortium's Transbus procurement.

1. Design Operating Profile

   Transbus must meet "typical urban street" environmental and operating conditions. There is no definition of a "typical urban street" and the Consortium is not willing to provide a definition. Further, the Consortium is not willing to mutually work out a definition. It is clear, therefore, that the Consortium simply wants to protect itself from any and all future structural and suspension problems. GFC could not accept such a comprehensive requirement.

2. Underbody Clearance

   The axle zone clearance requirement does not relate to any existing design. Clearance heights must be established by a design that GFC will provide and not by any arbitrary figure derived without prior design.

3. Curb Weight

   The 26,000 pound limitation for "any delivered coach" is not reasonable considering the necessary additional weight for a second rear axle and the wheelchair lift. Today's Advanced Design Buses approach 26,000 pounds and the weight addition for the extra axle and lift device may add another 2,500 pounds. It is improbable that 2,500 pounds can be removed from the bus in other areas without greatly compromising its structural integrity and safety.

4. Seating Capacity

   The specification mandates a minimum of 46 seats and proceeds to specify bus length, width, and height for the interior as well as the exterior. The two requirements are contradictory. A more likely capacity is 42-44 seats. The fact is, the number of seats will not be known until the design of the bus is completed.

5. Floor Height

   It is GFC's belief that the 24-inch rear floor height maximum is not reasonably achievable while still holding a 1 degree floor slope. A minimum of 25 inches height is necessary to clear the differential, and meet the axle ground clearance and floor slope requirements.

6. Emergency Operation of Doors

   The specification requires that passengers be able to "easily" free themselves from doors even if the door sensitive edges are inoperative. The specification also says a locked rear door shall open with 500 or more pounds of pressure applied without damage to the door or door mechanisms. These requirements are not compatible.

7. Door Opening Height

   An 85-inch high opening is required at both front and rear doors. This height will allow a 6'5" person to clear the door when the ramp is deployed to a 22-inch high curb. In order to provide the 85-inch height, bulges in the roof line will be necessary above both doorways. Actually, a 6'5" person could clear an 80-inch doorway at the rear and someone should review the extreme scenario presented at the front.

8. Driver View of Curb

   The specification calls for a driver capability of seeing the curb when the bus is 6 inches away from the curb. With a 14-inch first step height, this is a physical impossibility.

Exhibit B-1 cont.

9. Wheelchair Maneuvering and Parking

Due to specified length, width, and height restrictions, wheelchair maneuvering dimensions inside the bus appear to be unattainable, but this can not be confirmed pending final design.

10. Loading

Lifts or ramps must be deployable to a 22-inch high curb with a maximum 1/2-inch upward movement. Due to bus floor height restraints, this can be achieved only with a ramp thickness of 0 inches. Impossible!

11. Passenger Seats and Options

The requirement is for all passenger seats to be adjustable to meet passenger hip to knee spacing. The second rear axle on Transbus requires large wheelwall protrusions into the bus forcing fixed seating at the rear. This eliminates flexibility of seat spacing and reduces the available number of seats.

12. Gradability, Acceleration, and Operating Range

Transbus will weigh more than the Advanced Design Buses because of the addition of a second rear axle. GFC cannot guarantee Transbus performance requirements. Current ADB's, which are lighter, do not meet these requirements. The additional requirement of 3.5 mpg is also unacceptable because the economy of the engine is beyond our control.

13. Electrical System Requirements

GFC cannot guarantee 100 percent capability "for all possible conditions". It is necessary that the customer specify requirements particularly in the areas of destination signs, fare collection, radio control, and lift versus ramp.

14. Interior Climate Control

The specification requires that the fresh-air ventilation system maintain passenger comfort within a temperature range of 65-80 degrees. The ventilation system is dependent on outside ambient air, which may be well beyond the temperatures specified. (See Exhibit "B" for Additional Specification Issues)

DESIGN CONSIDERATIONS

Beyond the previously identified technical specifications, a number of crucial engineering design challenges have been imposed on major component suppliers, as well as GFC.

1. Suspension system and brakes

A totally new suspension and braking system imposes the necessity for extensive testing and development. This area is far more critical than was experienced on the ADB, which used existing suspension system components.

2. Tires

The smaller tires required by Transbus have thus far been unattainable, and we have serious reservations relative to our ability to secure a product which will provide the necessary durability, reliability, and safety at reasonable cost.

3. Wheelchair lift

The wheelchair lift specified for Transbus will require a totally new design. Wheelchair lifts for previous buses have been designed using step risers in order to form a platform. The reduction to one step and a smaller step riser on the Transbus configuration means that some sort of supplementary platform will have to be stowed and deployed along with the wheelchair lift. Our experience to date with new wheelchair lift designs would indicate this to be an enormously difficult undertaking.

4. Ramp

The now optional ramp required for the Transbus configuration also requires extensive product design, test and development. At this juncture, no production ramp has ever been designed.

Exhibit B-1 cont.

GMC TRUCK & COACH
Division of General Motors Corporation

ROBERT W. TRUXELL
General Manager
Vice President-General Motors

660 South Boulevard East
Pontiac, Michigan 48053
313/857-3311

April 27, 1979

The Honorable Brock Adams
Secretary of Transportation
U.S. Department of Transportation
Washington, D.C. 20590

Dear Secretary Adams:

You will recall that at the last of our several mid-1978 meetings on the Transbus matter, Mr. Estes and I indicated the need to undertake engineering studies before General Motors could reach a sound Transbus decision. These studies are now completed. Regrettably, we have concluded it would be unwise for General Motors to bid on the Transbus design.

Let me emphasize that bus accessibility is not the issue. We support the broad Transbus accessibility goals. Our commitment to those general goals without unduly compromising other prime operating elements of the bus has been demonstrated in several ways.

Our RTS transit bus, for example, with its kneeling capability reduces the effective floor height of the design it replaced by a substantial seven inches -- about 21%. The low RTS floor, the General Motors wheelchair lift and other innovations offer vastly improved accessibility and comfort for the elderly and handicapped. Research and development programs under way indicate other significant RTS accessibility advancements could be made in the relatively short-term.

The real issue in our decision not to participate in Transbus bidding was how General Motors could, by adhering to the fixed Federal Transbus design and procurement policies, assure transit authorities and the riding public that this vehicle would perform at the levels intended. Our studies clearly showed that we could not provide that assurance.

The Transbus design represents a very complex, unproven vehicle, and your decision to permit a five-year development period recognized that fact. Nevertheless, inherent in the Transbus design are major engineering, operating and performance concerns. In addition, the low-bid procurement process under which early Transbus contracts would be awarded, combined with a fixed design, leaves us little latitude to exercise our strongest talents -- namely, innovative high-technology research and development.

Federal Transbus procurement policies are apparently irreconcilable and this presents another dilemma. Although initial Transbus contracts will be awarded solely to the lowest bidder, the government states it may award future contracts according to a life cycle cost evaluation. However, it should be recognized that a lower quality bus designed to meet a strict low bid requirement would be inherently different from a higher quality, more durable, reliable bus designed to offer superior life cycle cost effectiveness. To be competitive under these two policies, a bus manufacturer would need one design for the initial Transbus contracts and another design for future Transbus contracts. As a result, two costly additional engineering programs with critical variations in design, material, tooling and production processes would be required, in addition to the extensive RTS development, if General Motors were to participate in the Transbus program.

In consideration of the aforementioned factors, we could only conclude that the Transbus vehicle design represents far too great a risk for us to develop and produce.

As I stated earlier, accessibility is not the issue. Our RTS is now capable of greater accessibility and we believe we can build on this technology toward an even more responsive vehicle. The RTS is not a static design. It is continually being evaluated for improvements which are consistent with broad Transbus objectives and which are feasible from the standpoint of available technology, operating requirements and cost effectiveness.
For example, the already lower effective RTS floor height may be reduced further by one-inch in the relatively near future, and another two-inch reduction may be possible within 12-to-18 months. These improvements would provide a 24-inch effective floor height -- 10 inches lower than the stationary floor height available before the introduction of the RTS.

Other major research and development efforts are in progress for additional RTS improvements. These efforts are measurably assisted by actual operating experience of Advanced Design Buses now in service which provides invaluable data for potential advancements.

We will be pleased to meet with you at an appropriate time and place to discuss in more detail our decision to seek further RTS innovations. However, the extent to which we are able to pursue further improvements will depend largely upon governmental policies bearing upon the development of public transportation.

Sincerely,

R. W. Truxell

Exhibit B-2 GM Letter to Brock Adams

When this Administration took office, the elderly and handicapped community was outraged over the refusal to mandate Transbus, and the litigation by AM General over the initial ADB procurement had produced a virtual halt in bus procurements. Further, because of previous uncertainty over federal bus procurement policies, each of the three domestic bus manufacturers was in a different competitive position and was ready to sell and develop different products, leaving the transit bus market in disarray.

One of Secretary Adams earliest actions was to have the General Counsel's office review the statutory framework of the Transbus issue. The statutory guidelines seemed clear. In addition to DOT's general responsibility, under the UMTAct, to assist in the development of improved mass transportation facilities and equipment, a 1970 amendment added section 16 to the UMTAct declaring the mass transportation needs of elderly and handicapped persons to be of special national importance and requiring DOT to exercise a particular leadership role in assuring that these rights were protected.

Two years later, section 504 of the Rehabilitation Act of 1973 added further statutory support by establishing the right of every handicapped person to be free of discrimination in any federally-assisted program. Transbus, we believed, offered an opportunity to fulfill these statutory requirements by mandating technological improvements which would enhance the accessibility of mass transportation facilities to the elderly and handicapped while producing a better bus overall.

Against this background—a clear policy goal, strong statutory guidelines, stymied bus procurement, and a major research program dropped before fruition—we decided to reopen the question of a Transbus mandate. We held a new round of public hearings and meetings with representatives of the three principal American bus manufacturers, elderly and handicapped groups, local transit officials and others.

On May 19, 1977, the Secretary issued the Transbus mandate. Based on the hearing record and the experience with the prototypes, we concluded that it was within the industry's technological capability to ensure that elderly and handicapped persons were accorded access to urban mass transit buses through the introduction of a new low floor design.

We recognized at the time of the mandate that there were remaining product development issues. But all three manufacturers had built prototypes and the feasibility of building the bus was never in question. We believed that the manufacturers could meet the challenge of producing Transbus. And we believed the pressure of effective competition among them would result in its prompt introduction

To meet the low floor requirement and the State and Federal axle weight limits, a new double rear axle, smaller wheels, brakes and tires would have to be developed. These new components would be unique to Transbus, therefore making manufacturers less willing to invest in their development. In contrast, several current bus components can also be used on intercity buses and trucks.

The framework of a limited market and a small number of manufacturers is one which, by its very nature, is not likely to lead to significant or rapid experimentation or to bold new initiatives. UMTA, through its efforts to encourage consortia of buyers and progress payments, has sought to make procurements more attractive to the manufacturers. The consortium of Los Angeles, Philadelphia, and Miami, with a combined order of 530 Transbuses to be followed by other consortia was an important feature of our effort to launch Transbus.

Undoubtedly the fact that both GM and Grumman-Flxible have made considerable investments and have begun marketing their ADB's within the past three years creates a strong corporate interest in trying to maximize the sales of those vehicles before making new design changes and considering additional investments.

Exhibit B-3 Excerpts from DOT Counsel Kamm's Testimony

Closing Statement of Chairman Norman Y. Mineta

As this phase of our oversight hearings on the UMTA program concludes, it is appropriate to reflect upon what we have heard, and what it all may mean.

Our thanks go out to the many capable witnesses who have testified, representing the Department of Transportation and UMTA, the manufacturers of bus and rail equipment, the operating systems, and the handicapped community. Today we extend our special thanks to the panel that has so ably reached back into its 10 years of aggregate experience to communicate ideas and insights to us.

Although any conclusions at this point are tentative at best, a few observations seem to be appropriate.

Number one, there is good reason for policymakers at all levels to be cautious when technology forcing is seen as the solution to any problem. There certainly is a time and a place for forcing technology. But the concept obviously has major deficiencies when attempted in an already weak marketplace such as exists for bus and rail equipment. This marketplace is relatively small, serving a public transportation sector that has been in decline since World War II, and is generally unstable and vulnerable to shifts in public policy. Compounding the problem has been a general weakening in the belief that technology offers a solution to all of our problems, and a growing resistance in this country to the idea of deliberately making things more complicated than they already are.

Point number two is that technological innovations should be attempted only where the new benefits clearly exceed the new costs. Boston's experience with its new light rail vehicles stands as one case in point. In the case of Transbus, which has dramatized many of the issues before us, it has not been established that the new benefits anticipated in 1971 would have resulted from the specifications of 1979.

All research and development efforts face the question of when to get off the escalator of advancing technology and to "freeze" a product by going into production. Until we reach the point where development of a new product like Transbus can clearly deliver a substantial increment of new benefits, its introduction is bound to be controversial.

Some of the most disturbing testimony that we heard related to the unavoidable reality of tradeoffs: for example, where a design feature carries with it an inordinate amount of maintenance costs. In this regard, UMTA's low bid procurement policy obviously adds to the difficulty of stimulating manufacturers to engineer higher levels of quality into their products. More attention is needed to this fundamental deficiency. We will all be interested in the results of the UMTA study now underway pursuant to the 1978 Surface Transportation Assistance Act.

Point number three is that the development of transit vehicle technology and its introduction into the marketplace is a lengthy process, usually spanning more than one administration. In the 1970's investments in rolling stock have become highly dependent on the federal role. Transit vehicle programs cannot withstand federal vacillation. We cannot afford to allow each new administration to set sail in a new direction. Incoming administrations of both parties should recognize that these kinds of decisions are often judgmental, and that in many instances continuity and consistency will be as important as whether a decision was yes or no.

This country needs effective and efficient public transportation now more than ever, and we need a transit vehicle marketplace that can increase our transit capacity as petroleum supplies become tighter. For that kind of marketplace to exist, the federal government will have to use a steadier hand at the tiller.

One obvious question that arises from our hearings is, "What happens to Transbus?" The Secretary has announced his intention to submit the issue to an independent scientific review panel to advise him whether it is possible to produce such a bus for a reasonable price. The report back time is 40 to 60 days. Good luck to such a panel. If the question of Transbus's technical and economic feasibility has not been resolvable over a period of 10 years, it will be a formidable task to resolve it in two months, to say the least.

Ultimately the decision will still come down to a judgment on some of the points just mentioned: Should technology be forced? If so, for what net benefits? Who is to be aided and at what additional cost? And at what risk of being reversed by future policymakers?

These hearings have demonstrated the difficulty that the Department of Transportation and UMTA face in trying to reconcile the many requirements that emanate from Capitol Hill, as well as the problems associated with such conflicting objectives as equipment standardization and being responsive to varying local circumstances.

It would be a mistake to interpret what has been said here as any weakening of the statutory mandate to accommodate the elderly and handicapped under Section 504 of the Rehabilitation Act of 1973 and Section 16 of the UMTA Act. That mandate, seeking to redress a long history of insensitivity to the needs of the elderly and handicapped, remains the law of the land whatever may be decided about Transbus, and that fact should not be forgotten by anyone.

In DOT and UMTA we have people of competence and high purpose who are confronted by a hodge-podge of sometimes conflicting goals and values. Saving energy, improving the natural environment, revitalizing city centers, providing mobility for all Americans—these are just a few of the laudable objectives that the agency must consider.

We hope this oversight endeavor has added something to our comprehension of their many problems, as well as a measure of confidence and trust in one another, as we seek the path of progress.

Exhibit B-4 Chairman Mineta's Closing Statement at Subcommittee Hearings

GFC "SPECIFICATION IMPOSSIBILITIES"

Quoted from GFC Release

"The following are 14 of the more onerous issues in the present Transbus Technical Specifications. These issues present requirements which are most unusual or are impossible to provide within the framework for the Consortium's Transbus procurement."

* * * *

Quoted from GFC Release:

"1. Design Operating Profile

Transbus must meet "typical urban street" environmental and operating conditions. There is no definition of a "typical urban street" and the Consortium is not willing to provide a definition. Further, the Consortium is not willing to mutually work out a definition. It is clear, therefore, that the Consortium simply wants to protect itself from any and all future structural and suspension problems. GFC could not accept such a comprehensive requirement."

Comment:

Virtually every new bus introduced to transit service has had structural deficiencies that necessitated major retrofits. These structural deficiencies have been the result of inadequate prototype testing in that insufficient mileage is accumulated on preproduction vehicles or that the mileage is "too easy" and does not represent transit conditions. The Transbus Procurement Requirements (TPR) specifies the minimum mileage to be run, the schedule (duty cycle) and that the track surface represent typical streets including potholes and other perturbations.

Acceptable course designs must include road surface discontinuities placed to assure frequent passage of the test bus at various speeds. It did not seem prudent to specify an exact test course when satisfactory existing courses are availble which may be somewhat different. Also it would not be proper to specify an existing course as a sole source. Rather we expected a manufacturer to propose a course conveniently located to his facility.

Flxible made a similar comment in their response to the UMTA/Federal Register requests of March 21 and April 10, 1978. It was considered but the specification was not changed from the present specification wording. The approach used in the specification is not conside ed to be an impossibility.

* * * *

Quoted from GFC Release:

"2. Underbody Clearance

The axle zone clearance requirement does not relate to any existing design. Clearance heights must be established by a design that GFC will provide and not by any arbitrary figure derived without prior design."

Comment:

Transit operators have long been concerned that Transbus will have less underbody clearance than their current (New Look) buses and that any reduction would cause them operating problems and increased maintenance cost. As a result of this concern, UMTA directed that production Transbus have underbody clearances no less than the New Look buses with the best underbody clearance (GMC). Many buses have been audited and the Transbus specification best defines this minimum requirement. One of the Transbus prototypes (GMC) demonstrated the feasibility of the specification.

Since this particular specification item is not expressed in performance terms, it is likely that a specific design which did not exactly meet the specification requirement could still prove to be satisfactory in service. For example, neither of the ADB's conform to the Transbus requirement but to date no operational problems due to insufficient underbody clearance have been reported. UMTA and the Consortium would consider for approval any sensible specific design which might slightly deviate from the specification.

However at the present design stage, where the designer still has considerable latitude, it is probable that it can be met if the designer makes the effort. The specified ground clearances are highly

Exhibit B-5 UMTA's Response to GFC's 14 Impossibilities

desirable, and can probably be achieved without deviation in Transbus.

Previously, in response to the UMTA Federal Register requests of March 21 and April 10, 1978, Flxible requested that the same ground clearances as for ADB's be used. After consideration it was decided to use the slightly more stringent clearances which appear in the Transbus specification. We do not consider that this results in an impossible condition.

* * * *

Quoted from GFC Release:

"3. Curb Weight

> The 26,000 pound limitation for "any delivered coach" is not resonable considering the necessary additional weight for a second rear axle and the wheelchair lift. Today's Advanced Design Buses approach 26,000 pounds and the weight addition for the extra axle and lift device may add another 2,500 pounds. It is improbable that 2,500 pounds can be removed from the bus in other areas without greatly compromising its structural integrity and safety. "

Comment:

Transit operators agree that the current ADB's are overweight and that the excess weight is substantially increasing their fuel, tire and brake costs. It is also very difficult for publicly owned transit to justify purchase of heavier buses when other automotive vehicles, including trucks, are becoming lighter to conserve fuel and improve efficiency.

Before introduction of the ADB's, fully equipped transit buses (without lift) were available that weighed approximately 23,500 pounds. The only inherent penalty in the ADB's (also in Transbus) is the cantilevered seating. The inherent weight penalties for Transbus are the tandem rear axle at less than 1,000 pounds and the ramp system at about 500 pounds. A well designed Transbus should weigh less than 26,000 pounds.

Although the curb weight had been discussed previously with the consortium and APTA's Bus Technology Committee (BTC), the GFC Transbus no-bid release is the first time GFC has formally brought the subject up. Under the circumstances GFC could have a) tried to meet the weight, or b) requested a waiver.

It is not considered that the specification created an impossible condition. Curb weight requirements are explored further in Attachment 1.

* * * *

Quoted from GFC Release:

"4. Seating Capacity

> The specification mandates a minimum of 46 seats and proceeds to specify bus length, width, and height for the interior as well as the exterior. The two requirements are contradictory. A more likely capacity is 42-44 seats. The fact is, the number of seats will not be known until the design of the bus iscompleted."

Comment:

Transit operators have long been concerned about the apparent loss of seating capacity in both ADB's and Transbus. ADB's seat 46-47 passengers in the same degree of comfort as a New Look bus when it is configured for 47 to 49 seated passengers. Transbus should have the same, or very nearly the same, seating capacity as the ADB's. The Flxible Transbus prototype seated 45 passengers and had three design faults that reduced seating capacity:

- the wheelhouses were square cornered and flat sided and that precluded their use as footrests for seats immediately behind. This condition necessitated extending seat pitch in some areas.

- the tandem front axles caused the wheelhouses over the front wheels to be longer than those required for a single front axle and eliminated 2-paired transverse seats.

Exhibit B-5 cont.

- the "coach lounge" arrangement in the rear of the coach eliminated the rear bench seat which normally accommodates 5 passengers.

Dozens of seating layouts were developed during the Transbus program which showed seating capacity of 46 to 49 passengers in three axle buses with contoured wheelhouses.

In their letters to UMTA dated June 10, 1975 and September 17,1975, Rohr Industries (previous sole owners of the Flxible Company) stated that 48 seats would be appropriate for Transbus.

Although Flxible did not submit comments on seating from the UMTA-Federal Register requests of March 21 and April 10, 1978, they previously had requested a reduction from a proposed 46 seats. We believe that, with effort, a designer could achieve the highly desirable 46 seats.

* * * *

Quoted from GFC Release:

"5. Floor Height

It is GFC's belief that the 24-inch rear floor height maximum is not reasonabley achievable while still holding a 1 degreee floor slope. A minimum of 25 inches height is necessary to clear the differential, and meet the axle ground clearance and floor slope requirements."

Comment:

The Transbus specification allows a floor height of approximately 24 inches at the rear. This is the same dimension as the GMC Transbus prototype and about 4 inches higher than the Rohr (Flxible) Transbus prototype. Both of these buses had tandem rear axles with the differentials under the floor (where the clearance problem occurs). Although the production Transbus rear axle is not yet designed it most likely will be a derivative of either the GMC or Rohr Transbus axles. Therefore, it appears that the specified 24 inches can be attained. Even so the one inch additional clearance, which GFC asks for, results in an increase in floor slope in the order of 0.15 degrees, hardly a major deviation from the specification.

Flxible's response to the UMTA-Federal Register request of March 21 and April 10, 1978 requests a rear floor height of 25 inches in lieu of the 24 inches then proposed. This is followed by their statement "This will result in a floor slope of less than 1 degree ---". This comment was pertaining to a single rear axle Transbus instead of the tandem rear axles now specified but, it is believed that the floor slope issue and dimensions are the same. In conclusion, the 24-inch rear floor height and 1 degree floor slope probably can be attained if the designer puts forth an effort; but a change to accommodate the GFC dimension, if necessary, is probably of no significant consequence. It does not appear that an impossible condition is created by the specification.

* * * *

Quoted from GFC Release:

"6. <u>Emergency Operation of Doors</u>

The specification requires that passengers be able to "easily" free themselves from doors even if the door sensitive edges are inoperative. The specification also says a locked rear door shall open with 500 or more pounds of pressure applied without damage to the door or door mechanisms. These requirements are not compatible."

Comments:

Here GFC is combining two separate requirements appearing in different paragraphs of the specification. The first involves the subject of exiting passengers being caught in the closing door. Sensitive door edges that sense an interference to door closing (and reopen the door) are commonly used to protect exiting passengers. Sensitive door edge devices are, however, difficult to maintain and, therefore, are frequently inoperative.

It is intended that the door sensitive edge be mounted in a deep flexible material so that, if the sensitive edge is not operating, a passenger trapped in the closing door can still extract himself. Many automatic doors in public use employ this principle.

The second requirement that the doors, when closed, be indeed firmly closed so that passengers can't accidentally easily fall out is a separate requirement and is not at all incompatible with the first.

Since it is possible to achieve these requirements in different mechanical ways the specification tries to avoid telling how to achieve them. GFC re-stated and combined the requirements which may make them appear incompatible.

In their response to the UMTA-Federal Register requests of March 21 and April 10, 1979 Flxible asked for deletion of the 500-pound requirement without offering any alternative. These are hardly impossible requirements and are important and achievable safety items which should be in the specification. As shown in attachment 2 door related accidents are common in bus service.

* * * *

Quoted from GFC Release:

"7. Door Opening Height

An 85-inch opening is required at both front and rear doors. This height will allow a 6'5" person to clear the door when the ramp is deployed to a 22-inch high curb. In order to provide the 85-inch height, bulges in the roof line will be necessary above both doorways. Actually, a 6'5" person could clear an 80-inch doorway at the rear and someone should review the extreme scenario presented at the front."

Comment:

The 85-inch high door opening is required at the front door to assure ingress/egress of walking passengers via the ramp. People normally lean forward when descending stairs and when the step risers are relatively short, 12 inches or less, an 80-inch high door header becomes a hazard. It must be remembered that Transbus has only one interior step (in place of the two interior steps of current buses) and a passenger approaches closer to the door opening before starting to descend the step well. UMTA would consider changing the specification to 80 inches at the rear door only, provided that the rear step tread was sufficiently wide to avoid a head knocking condition. Flxible's statement about "bulges in the roof" would probably be true should they adapt their ADB body to Transbus with minimal modification.

Previously, in reply to UMTA-Federal Register requests dated March 21 and April 10, 1978, Flxible asked for a reduction in door height to 82 inches. After reviewing this request it was decided to use the 85-inch height presently specified. With a design effort a bulge in the roof may be avoidable but even a bulge hardly seems to qualify as an impossibility.

* * * *

Quoted from GFC Release:

"8. <u>Driver View of Curb</u>

The specification calls for a driver capability of seeing the curb when the bus is 6 inches away from the curb. With a 14-inch first step height, this is a physical impossibility."

Comment:

The intent of the specification is to assure that the lower portion of the front door is glazed and good visibility of the curb is provided.

Although our layouts do not show the specification to be impossible, a required important dimension is in error since it does not account for the practical visual obstruction necessitated by the bottom of the door frame. Recently UMTA and the BTC reviewed the necessity of having good driver visibility through the lower part of the front

Exhibit B-5 cont.

door and found it to be a safety item and that requirements should be imposed. At least one new bus front door, which was being manufactured and placed in public use, was not satisfactory.

We have not received a request from Flxible in the past to review this item. UMTA and the consortium would have considered a proposed GFC design for approval if that became necessary.

* * * *

Quoted from GFC Release:

" 9. Wheelchair Maneuvering and Parking

> Due to specified length, width, and height restrictions, wheeelchair maneuvering dimensions inside the bus appear to be unattainable, but this cannot be confirmed pending final design."

Comment:

All the wheelchair maneuvering dimensions except for door width have been attained in 102-inch wide New Look buses. Also, all of the dimensions specified have been attained in the full size typical Transbus (102 inch wide) mockup at Booz Allen (used for testing wheelchair ramps and internal wheelchair maneuvering). Therefore, we see no barriers to attaining the specified dimensions.

Although Flxible has previously commented to UMTA on Transbus wheelchair loading requirements, this is the first time, according to our records, that they have raised the issue of interior maneuvering dimensions.

* * * *

Quoted From GFC Release:

"10. Loading

> Lifts or ramps must be deployable to a 22-inch high curb with a maximum 1/2-inch upward movement. Due to bus floor height restraints, this can be achieved only with a ramp thickness of 0 inches. Impossible!"

Comment:

The phrase "with a maximum of 1/2 inch upward movement" does not appear in the ramp specification, nor does the specification impose any restriction on ramp thickness. GFC may have misread the specification. With effort, a designer should find the maximum curb height requirement entirely feasible.

If a design were proposed which had trouble accommodating the 22 inch high curb requirement, UMTA and the Consortium would consider a request to review the problem. This is the first time GFC has raised the issue, to UMTA, of the Transbus maximum curb height to be accommodated by the wheelchair ramp.

* * * *

Quoted from GFC Release:

"11. Passenger Seats and Options

> The requirement is for all passenger seats to be adjustable to meet passenger hip to knee spacing. The second rear axle on Transbus requires large wheelwell protrusions into the bus forcing fixed seating at the rear. This eliminates flexibility of seat spacing and reduces the available number of seats."

Comment:

The issue here is whether or not seat spacing should be adjustable. In the GFC 870 bus the seat spacing is not adjustable so that seating arrangements are normally good but not always optimum. The issue was debated at length by the UMTA Transbus board and a decision was made that, for Transbus, seat spacing should be adjustable, since it is available on some current buses.

This is is the first time GFC has commented on this issue to UMTA. Adjustable seat spacing is hardly an impossible condition.

* * * *

Exhibit B-5 cont.

Quoted from GFC Release:

"12. Gradability, Acceleration, and Operating Range

Transbus will weigh more than the Advanced Design Buses because of the addition of a second rear axle. GFC cannot guarantee Transbus performance requirements. Current ADB's, which are lighter, do not meet these requirements. The additional requirement of 3.5 mpg is also unacceptable because the economy of the engine is beyond our control."

Comment:

This issue is essentially the same as item number 3 above, curb weight. It is considered that a Transbus (which is specified as lighter than the current ADB's) can meet the performance requirements and also deliver over 3.5 miles per gallon when operated over the design operating profile. As stated under item 3, the Consortium considers the problem of bus weight (and related fuel economy) to be very important.

The Consortium preferred a specification which is practicable but on the hard-to-meet side of lighter bus weight. The BTC prefers this position too, as does UMTA. If a designer made a serious attempt to meet the Transbus requirements for weight and fuel economy but found he required some degree of waiver, the Consortium and UMTA would consider such a request.

This ~~is the~~ first time Flxible has raised this Transbus issue to UMTA according to our record.

* * * *

Quoted from GFC Release:

"13. Electrical System Requirements

GFC cannot guarantee 100 percent capacity "for all possible conditions". It is necessary that the customer specify requirements particularly in the areas of destination signs, fare collection, radio control, and lift versus ramp."

Comment:

The Transbus specification requires that the electrical power generating system shall be rated at no less than the total possible electrical load under all possible operating conditions including the engine at idle. Because there are a variety of fare ooxes and radios the specification limits the electrical load to be provided for these systems to 12D watts (Spec 2.6.5) and 360 watts (Spec 3.8.1) respectively. The other items as enumerated by GFC are under the control of the designer and it is his choice and responsibility to establish the electrical load for these. It appears that the specification is complete and adequate for GFC to establish the specific electrical capacity needs for their Transbus design. In contrast to presenting an impossibility the specification permits the manufacturer to choose his best design approach and component selections.

In the Flxible response to the UMTA-Federal Register requests of March 21 and April 1D, 1978 (and also in a previous response) requests were made for changes to the Transbus electrical specifications but the above subject of not being able to determine the necessary electrical capacity was not brought up.

* * * *

Quoted from GFC Release:

"14. Interior Climate Control

The specification requires that the fresh-air ventilation system maintain passenger comfort within a temperature range of 65-80 degrees. The ventilation system is dependent on outside ambient air, which may be well beyond the temperatures specified. (See Exhibit "B" for Additional Specification Issues)."

Comment:

The above GFC characterization in no way reflects the statement or intent of the Transbus specification. The specification refers to an "interior climate control system" composed of "heating, ventilating, and cooling

Exhibit B-5 cont.

PART C: THE ADBs

1979-1980: The ADBs Hit the Streets

Mike Buckel had been working with local transit agencies during the previous few years. Then between June 21, 1979, and February 29, 1980, he was involved in the testing of the GFC 870 for Metropolitan Atlanta Rapid Transit Authority (MARTA) and of the GMC RTS-II for Southeastern Michigan Transportation Authority (SEMTA). The two agencies had contracted Booz-Allen to perform the specification testing. Mike found "numerous areas where they didn't meet the specification. . . When we were in Atlanta, we saw Flxibles coming in that were breaking up. In fact, one came in with the engine nearly dragging on the ground, the cradle was falling apart." Booz-Allen had found cracks in both the body and under structure during their tests, months before they occurred in actual service. Exhibit C-1 shows an excerpt from the original specifications and the corresponding test results.

Mr. Buckel saw terrible problems with the RTS-II thermal management. The "air conditioner was in series with the radiator, so the condenser was pouring heat into the radiator and then they had to have a huge fan that required 35 horsepower to get enough air through the two systems and as a result it vacuum cleaned the street -- sucked up all the . . . sand and dirt into the condenser and radiator. Then you spill a little oil, get some trash back there and you pack the condenser full of sand and dirt."

Obviously, all was not well with the ADBs. It was not until much later in 1980 that the problems Mike buckel had seen began to surface publicly. At that time, the Booz-Allen report became "really scarce" in Mr. Buckel's words.

Ed Kravitz was still Vice President of Engineering at Grumman-Flxible when problems began to occur. He became very disturbed by the way in which the problems were being dealt with, especially in New York which he saw as the catalyst for the bad publicity which was soon to follow.

Problems in New York

When it became evident in November 1980 that there were fatigue cracks in some of the buses, the New York City Transit Authority (NYCTA) pulled the entire fleet of 870s off of the street. Mr. Kravitz was shocked because past practice was to pull only the buses with problems, fix them and send them back out. He repeatedly attempted to contact the engineers at NYCTA but was not allowed to speak with them for a month because of potential legal problems. Mr. Kravitz felt that was the "single saddest part" of the ordeal. He thought it was wrong to have lawyers involved "in a technical problem they knew nothing about

and to allow them to lay the groundwork for correcting the difficulties."

Following the fleet pull, there was much bad press for Grumman in New York. A newspaper reported that an engine had fallen out - an impossibility according to Ed Kravitz. After a protest from Grumman, a retraction was printed. Mr. Kravitz was wondering why such a big fuss was being made over their repair procedures. He felt that the NYCTA was looking for something on which to blame their poor maintenance of streets and buses.

1981: The Repairs

In January 1981, Grumman began an extensive study into the causes and cures for the problems. Exhibit C-2 is a flow chart of the modification procedures. Grumman's proposed solutions were scrutinized by a panel of engineers for NYCTA. Also, Battelle Memorial Institute did an independent study of the 870. Exhibit C-3 shows the major components of the 870 and Exhibit C-4 contains Battelle's description of the vehicle loading and a diagram of where and when the cracks occurred.

In evaluating the original design, Battelle found four types of problems:

(1) Fatigue cracks - generally occurred in welded steel structural members. including undercarriage (front and rear), door frames, mullions, engine cradle; also found in aluminum side wall top rails and one side wall panel.

(2) Buckling or excess deflection - usually confined to the rear shear panels of the engine compartment. Some sagging of the rear and front ends of the bus were noted. Front sagging was usually traceable to cracked door frame posts.

(3) Bolt hole elongation - reported in fuel tank mounting holes, where the tank attaches to the side support brackets. These brackets attach the tank to the bus body.

(4) Rivets - some body rivets needed to be replaced because they were loose or corroded.[15]

The design problems were the result of underestimating the stresses from streets such as those in New York with potholes, etc., overlooking effects of stress concentrations and some misinformation about material properties of High Strength Low Alloy (HSLA) steel in welded versus unwelded states.

Exhibit C-5 shows the crack locations in the A-frame, engine cradle, trunnions and sidewalls. Almost all of the fatigue cracks in those areas were located in the vicinity of welds.

[15] Study of Grumman Flxible 870 Advanced Design Bus Structural Failures (Columbus, Ohio: Battelle, 1982), p. 2-3.

The analysis of the welds were summarized in the Battelle report as follows,

> GFC indicated that the material property data used in the original fatigue analysis of the 870 ADB was based on unwelded property data. Therefore, one potential problem that was overlooked in the fatigue analysis is the effect of welding. The undercarriage is constructed of two . . . HSLA steels, having minimum yield strengths of 50,000 and 80,000 pounds per square inch. . . Typical steels used in the past for transit vehicles have had yield strengths of 35,000 to 40,000 psi. The HSLA steels achieve higher strengths by refining the grain size of the steel through controlling the rolling procedure and/or by micro alloying to achieve a precipitation strengthening or grain refinement. The fatigue strength of the HSLA steels is generally better than the previously lower strength steels as is demonstrated in [Exhibit C-6]. Note, however, that when the steels are tested in a welded condition . . . the fatigue resistances of the HSLA and lower strength steels are almost identical. It appears that during welding some of the benefits of the refined grain size are lost. Possibly the design engineers were depending on the fatigue strength of HSLA steel to scale in proportion to their yield strengths, if so they were not the first to be misled.[16]

The harshness of the New York environment on the buses was something that Flxible engineers had not fully taken into account when designing the buses. Exhibit C-7 shows how much earlier failures occurred in New York as compared to the other cities. In fact, while the modification program progressed over a two year period, Ed Kravitz found that some of the other transit systems were running the 870 continually with no problems in these areas.

Poor design with respect to stress concentrations was another criticism of the 870. Some of Grumman's modified designs to strengthen members and relieve stress concentrations are shown in Exhibit C-8.

After much review, the New york Panel approved Grumman's modifications and the repairs were made. GFC modified all of their 870s around the country.

The GM buses' problems (and there were many) never got the publicity that the 870 did. According to Mike Buckel, there were law suits against GM in Westchester and Philadelphia based on a design defect in the air conditioning system of the RTS-II. To solve the problems, General Motors offered a modification package for about $6,000 ($10,000 by the time it was installed). In San Antonio, for example, one-third of their RTS-IIs were or

---

[16] Ibid., p. 4-38.

In San Antonio, for example, one-third of their RTS-IIs were or would be modified. In 1980, GM came out with the RTS-04 in order to "get around fixing the problems."

Both General Motors and GFC lost many millions of dollars, but the engineering problems were fixed. Ed Kravitz came out of the ordeal "disappointed at the lack of professionalism displayed by the press and the inaccurate reporting bordering on sensationalism. Many 'facts' reported were proven to be untrue." In addition, Mr. Kravitz stressed that "no reports of passenger injury were ever produced on any 870 coach whereas several incidents occurred on the GM RTSs."

Specification Reference	Requirement	Non-Conforming Condition	Comment
2.1.1.1 Body Design	Minimize wheel-generated spray and splash on windows	Window visibility	Visibility out passenger windows markedly reduced after operation on wet, salty roads
2.1.2.1 Body Strength and Fatigue Life	Withstand impact and inertial loads due to normal street travel	Body structure	Cracks in body and rear portion of coach
2.1.9.2 Exterior Access Door	Conventional or pantograph hinged doors	Access doors	Front access door for windshield washer resevoir and tow hooks not hinged, top A/C access door not hinged

2.1.2 STRUCTURE

2.1.2.1 Strength and Fatigue Life

Under normal conditions of transit service throughout the service life of the coach, the basic structure shall withstand fatigue damage that is sufficient to cause Class 1 or Class 2 failure. The structure shall also withstand impact and inertial loads due to normal street travel throughout the coach's service life without permanent deformation or damage.

(18) *Classes of Failures.* Classes of failures are described below.

(a) *Class 1: Physical Safety.* A failure that could lead directly to passenger or driver injury and represents a severe crash situation.

(b) *Class 2: Road Call.* A failure resulting in an enroute interruption of revenue service. Service is discontinued until the coach is replaced or repaired at the point of failure.

<u>Exhibit C-1</u> Excerpts from Booz-Allen MARTA Report (top) & "White Book" Specification (bottom)

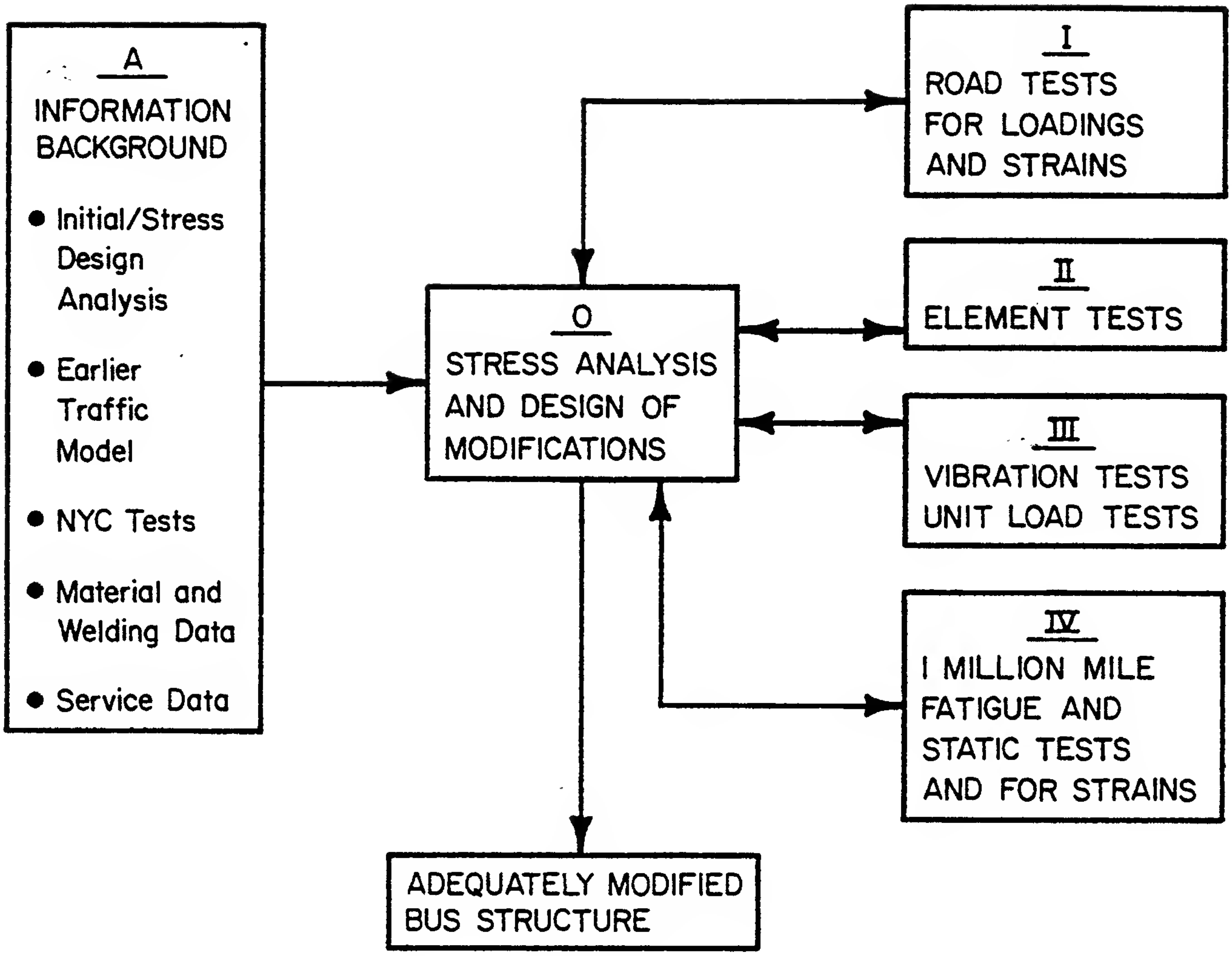


Exhibit C-2 Modification Flow Chart

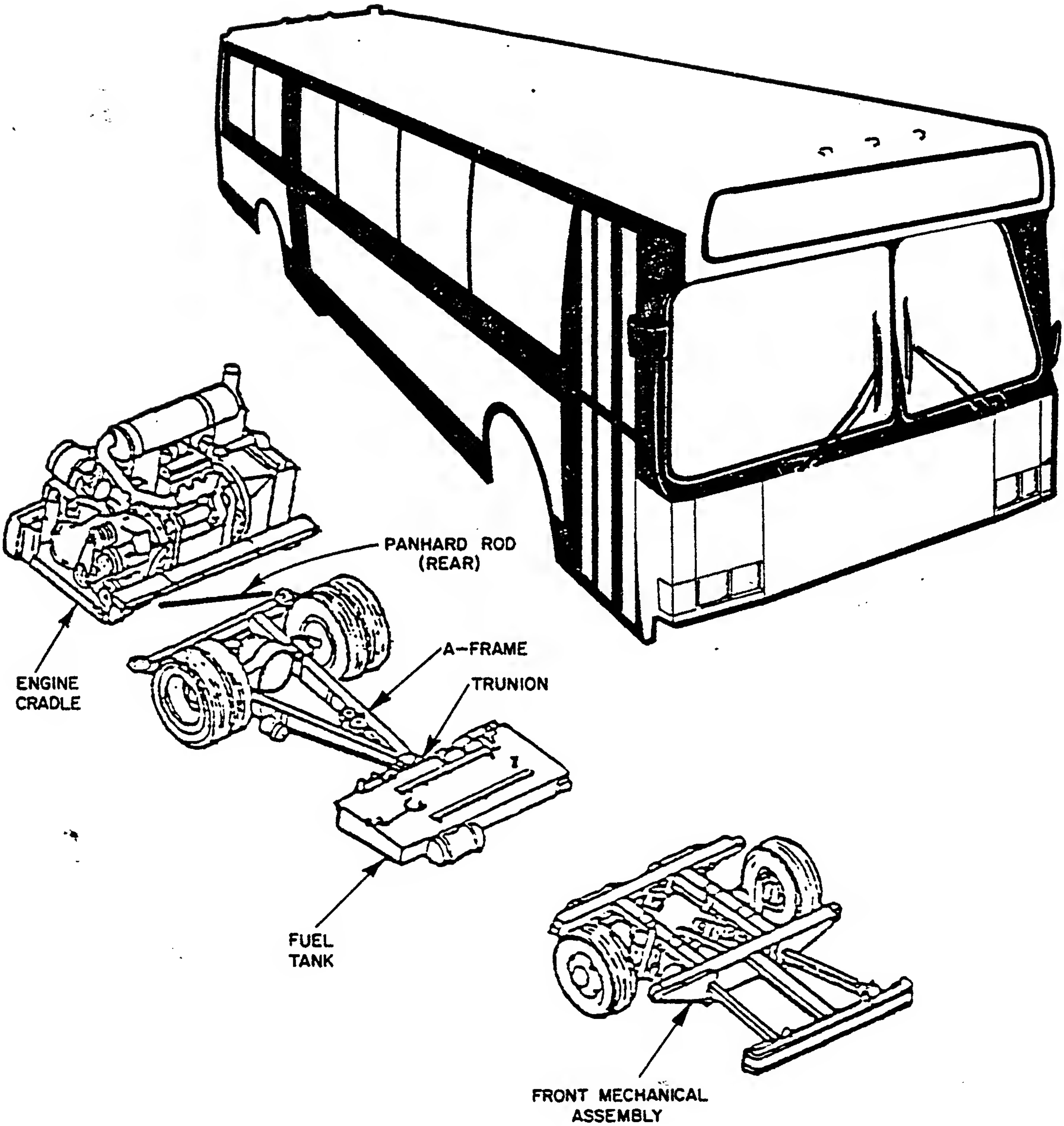


Exhibit C-3 Major Components of GFC 870

The 870 ADB embodies many unique design and fabrication concepts that have received a great deal of praise. One unique feature is that the bus is fabricated in sections. Each section is essentially completed before it is joined with the other completed sections. These sections can be divided into two categories, those used in the bus body and those used in the undercarriage. The body is comprised of six sections, namely, the floor, roof, curbside-sidewall, roadside-sidewall, and the front and rear closures. The undercarriage on the other hand, is comprised of five sections, the A-frame, engine cradle, front mechanical assembly, fuel tank and trunnion. Many of these sections are visible in Figure 1-1.

Another unique feature is the interlocking joint design used in many of the sections of the 870 ADB. These patented joints connect the roof and floor to the sidewalls and are also used to connect the sidewall extrusions to each other. The various connections are illustrated in Figure 1-2. During the assembly process these joints are interconnected and then injected with epoxy to lock them in place.

The method by which the over-the-road service loads are supported, is also somewhat unique for a bus. The 870 ADB does not have a subframe that runs the length of the bus as in a conventional design, but rather the body of the 870 ADB is used to transmit the loads between the front and rear sections of the undercarriage. At the front of the bus, the body simply rides on the front mechanical assembly. Whereas, at the rear of the bus the suspension is somewhat more complicated. The vertical forces applied to the rear wheels are transmitted into the body by means of two load paths. One is through the front of the A-frame by way of the trunnion and fuel tank. The other is through the rear of the A-frame by way of the air bag springs and the engine cradle. The engine and engine cradle are essentially hung from the rear of the bus, by means of two strut rods, one on each side of the bus.

Since there is no continuous subframe under the 870 ADB, vertical bending loads, such as those due to the weight of the bus and passengers for example, are carried by the bus body. The vertical bending loads generate forces in the body. In simple terms, these forces can be thought of in terms of tension, compression, and shear. Bending of the body due to weight loading produces a tensile force in the floor a compressive force in the roof, and shear forces in the sidewalls. Shear forces in general tend to distort things like window and door openings from their original rectangular shape into parallelograms. It is also possible that shear forces could be produced in the bus body that would cause the rectangular shape of the cross section of the body to be distorted into a parallelogram. This distorsion would be resisted by the stiffness of the front and rear closures and by the stiffness of the floor to the sidewall, and roof to sidewall joints. Since the 870 ADB does not have a conventional subframe conditions encountered during normal operation, other than those due to bus and passenger weight, also cause forces to act on the bus body.

Longitudinal (fore-aft) forces are produced in the bus body during acceleration, deceleration, and braking. At the rear of the bus, these forces act at the wheels, and are transmitted from the wheels into the A-frame, the trunnion, the fuel tank and then into the bus body. At the front of the bus, longitudinal forces also act at the wheels. These forces are transmitted from the wheels into the axle, the radius rods, the front mechanical assembly, and then into the bus body. Longitudinal forces cause tension or compression in the body, as a whole, depending on their direction.

Lateral (side) forces, such as those encountered during turns or curb-impacts are also transmitted into the bus body. At the front end of the bus these loads are transmitted from the axle to the front mechanical assembly by the panhard rod. One end of the panhard is attached to the axle while the other end is attached to the front mechanical assembly, and thereby provides a load path from the wheels into the body. Lateral forces are transmitted into the bus body at the rear of the bus, in a similar manner. A rear panhard rod attaches to the A-frame on one end and to the engine cradle on the other. The load path is therefore as follows, from the wheels to the A-frame, to the panhard rod, engine cradle and into the bus body. Another load path also exists at the rear of the bus. It is from the A-frame, to the trunnion, fuel tank and into the bus body. The lateral forces cause bending of the body from side to side. This side bending causes the sidewalls to be loaded in tension/compression, while at the same time produces shear forces in the roof and floor. These forces are analogous to those caused by vertical bending.

It is also worth noting that torsional forces can also be applied to the bus body during normal operation. Torsion of the body produces shear forces in the sidewalls, roof, floor, and the front and rear closures. As before, shear forces such as these tend to cause distorsion of the various sections of the body.

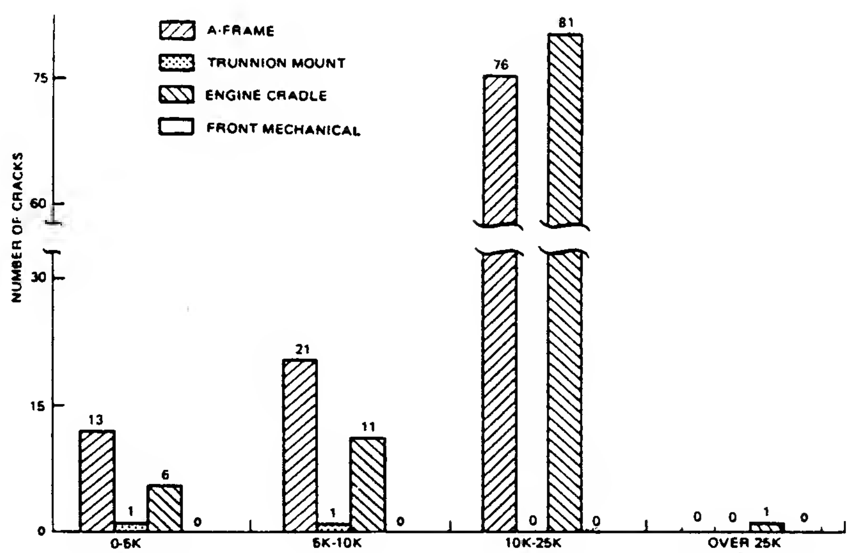
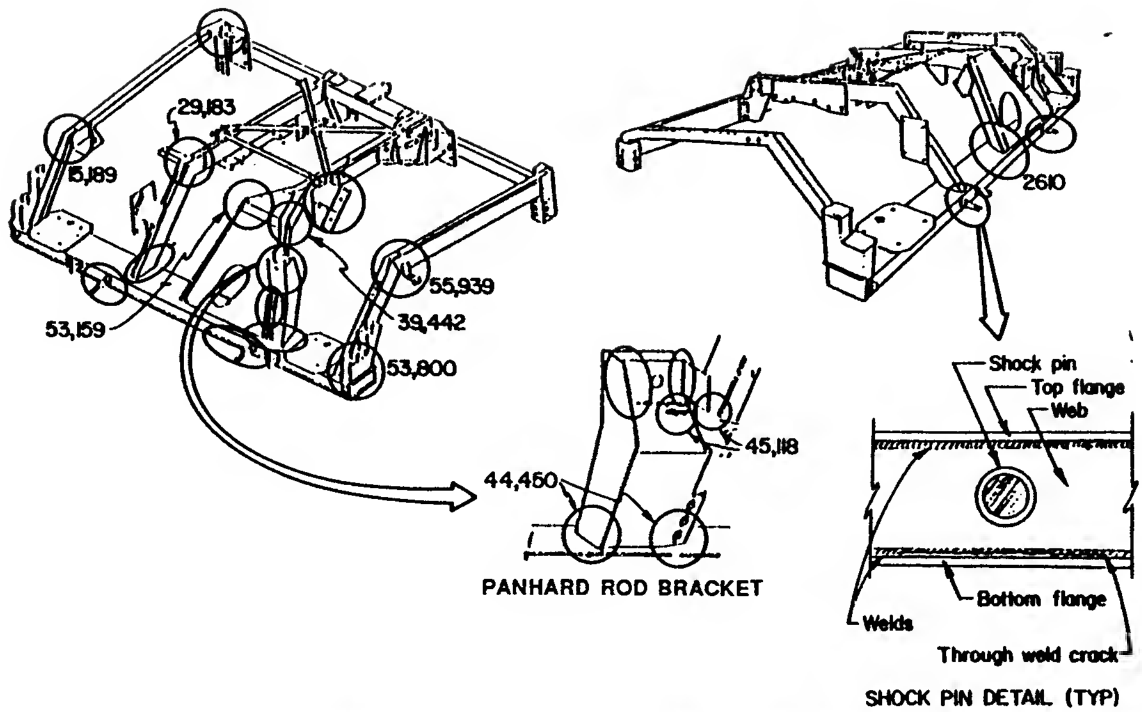
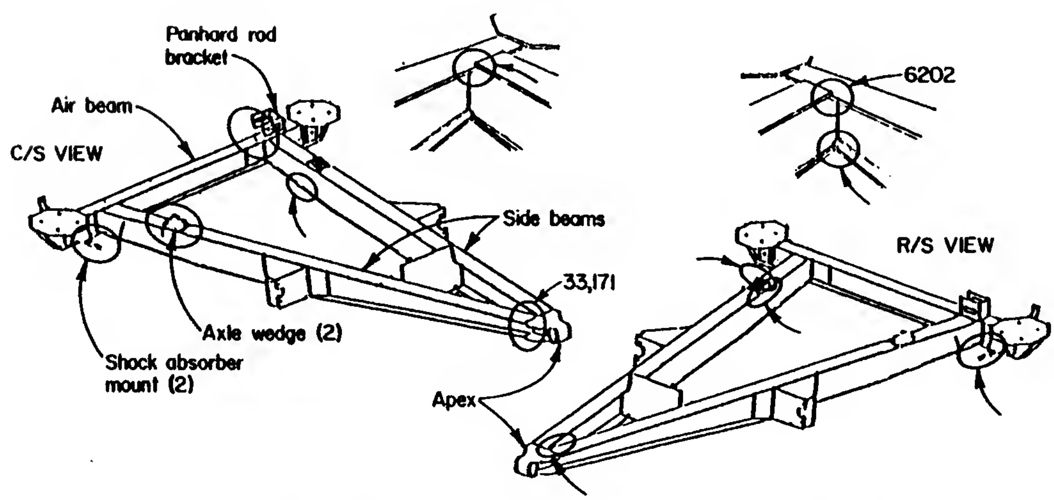


Exhibit C-4 GFC 870 Loadings and Crack History

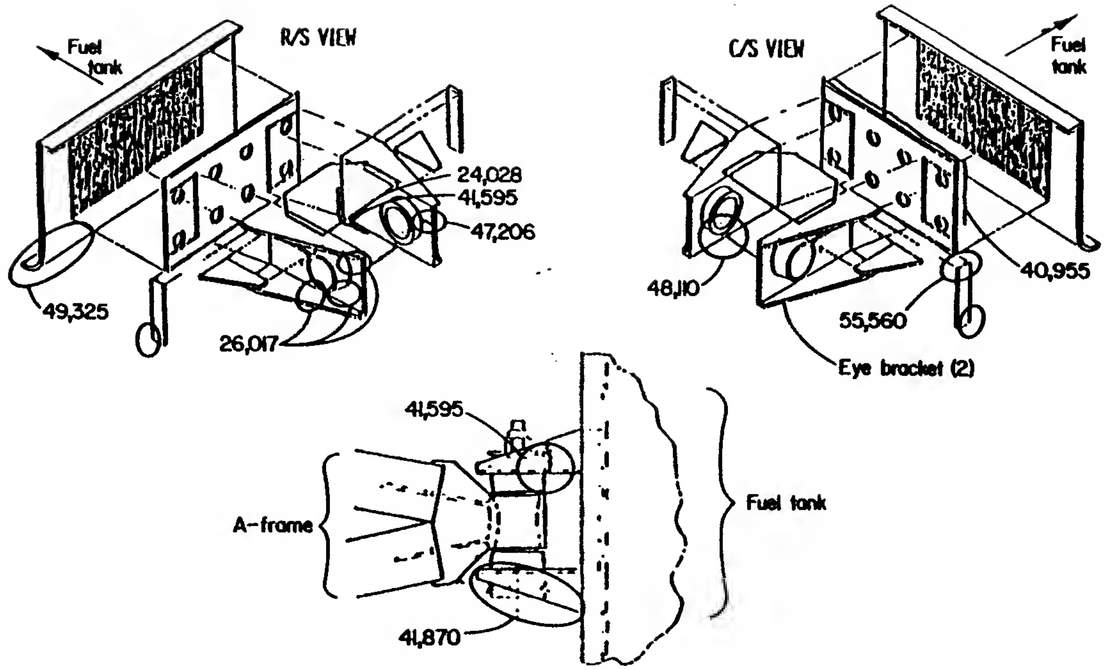


ENGINE CRADLE CRACK LOCATIONS, CRADLE SHOWN IN AN INVERTED POSITION, (NUMBERS INDICATE AVERAGE MILEAGE WHEN CRACKS WERE DETECTED)

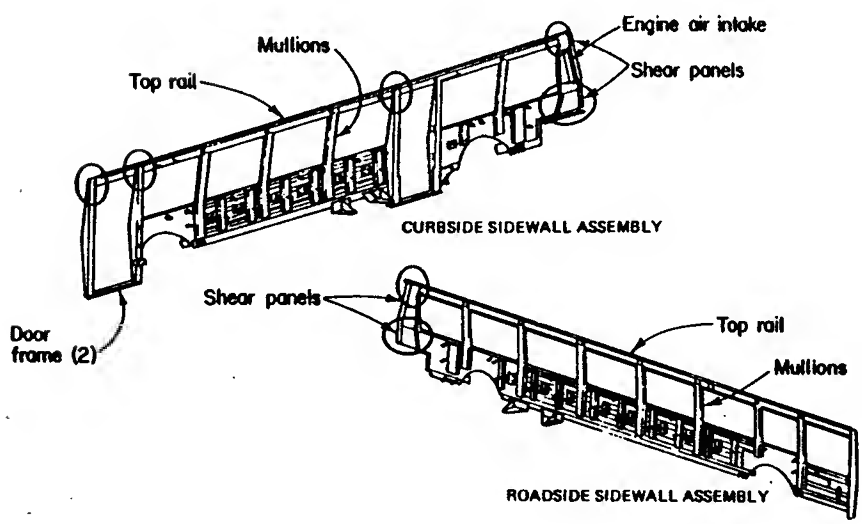


A-FRAME CRACK LOCATIONS, NUMBERS INDICATE AVERAGE MILEAGE WHEN CRACKS WERE DETECTED

Exhibit C-5 Crack Locations in Affected Parts

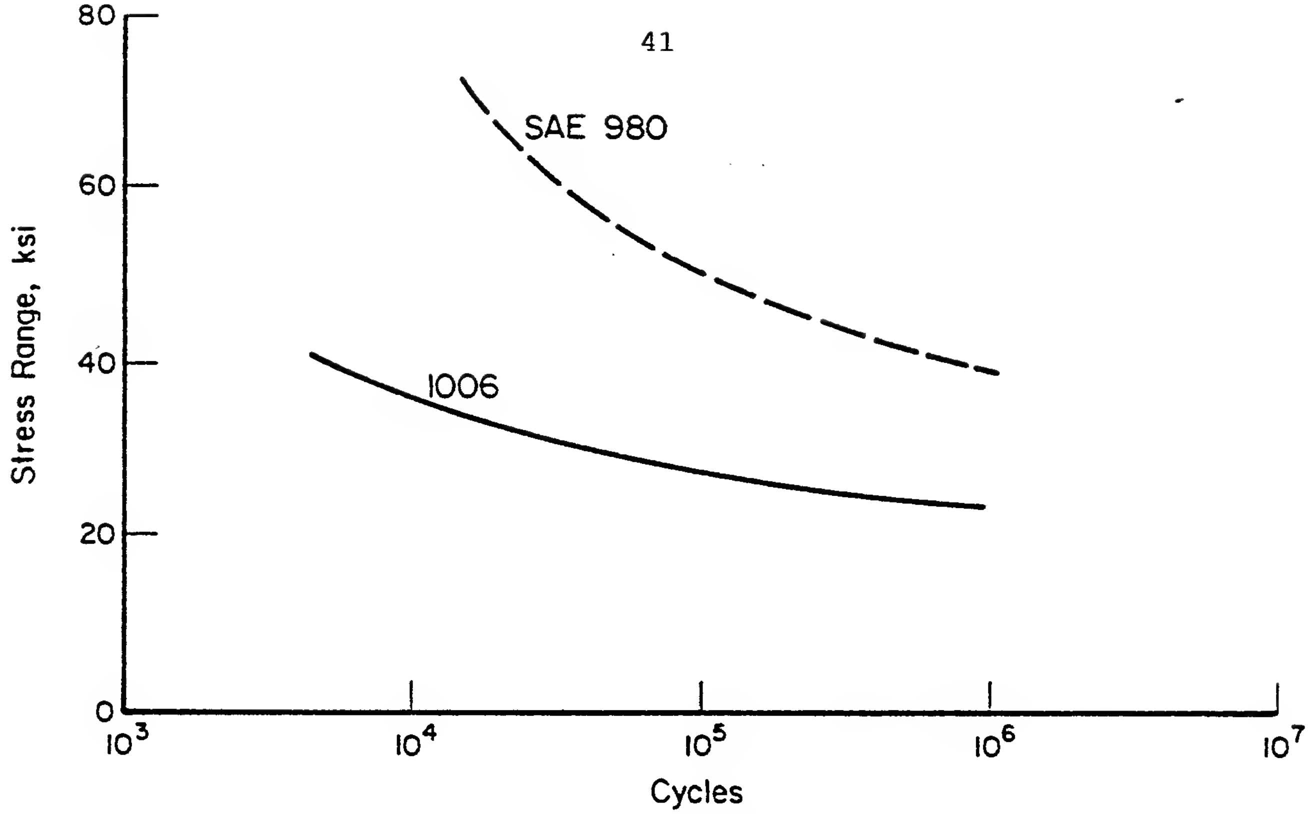


TRUNNION MOUNT CRACK LOCATIONS (NUMBERS INDICATE AVERAGE MILEAGE WHEN CRACKS WERE DETECTED)

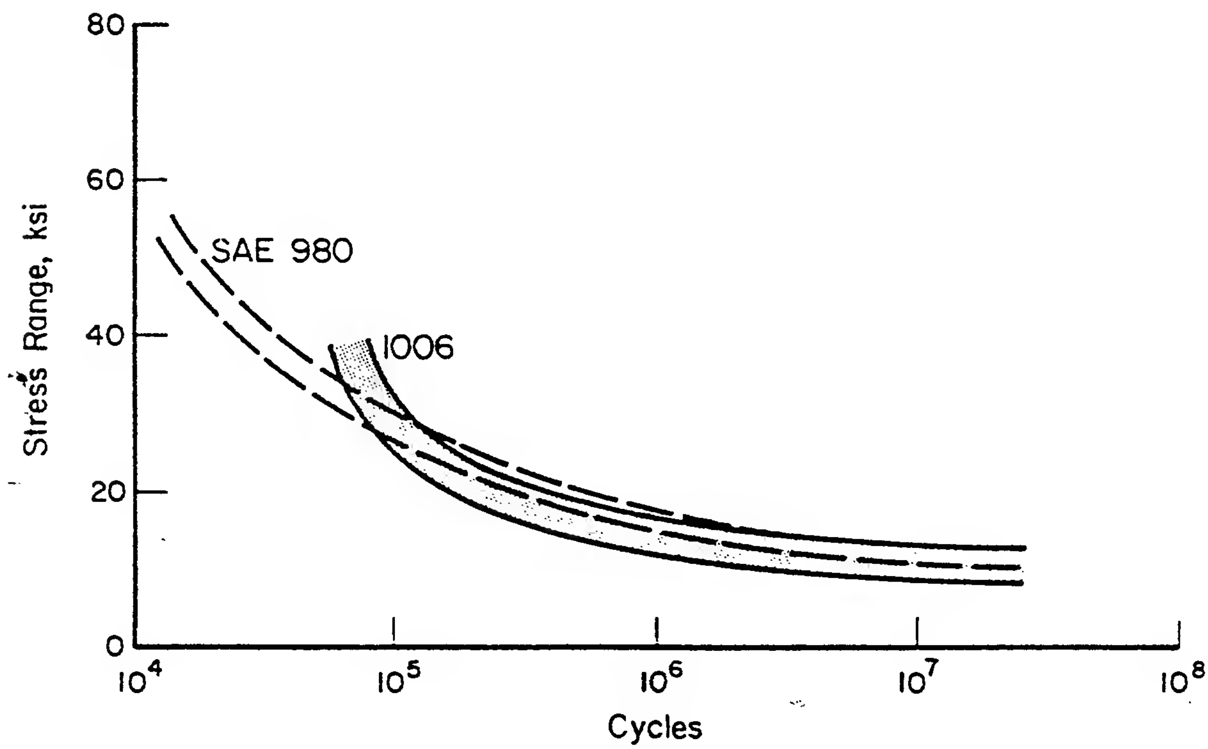


SIDEWALL PROBLEM AREAS

Exhibit C-5 cont.



a. Base Metal



b. Welded

Exhibit C-6 HSLA Steel Properties

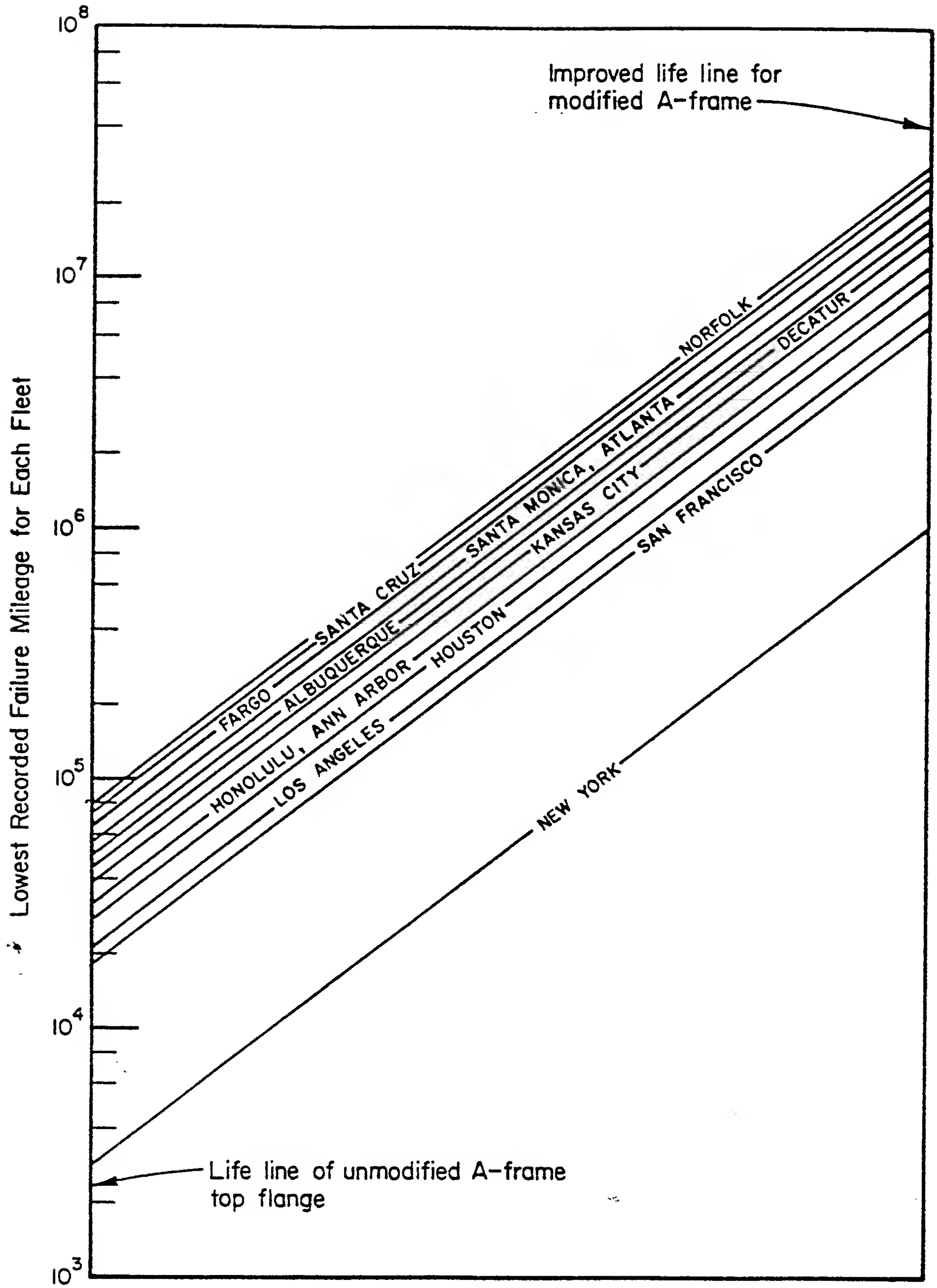
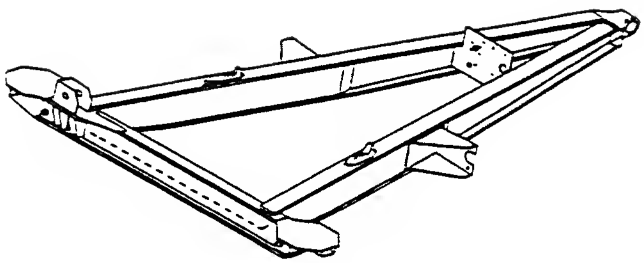
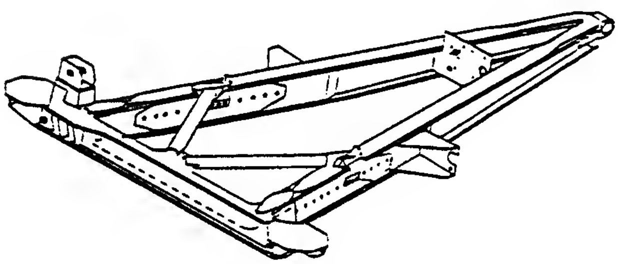


Exhibit C-7 Relative Crack Mileage from Various U.S. Cities

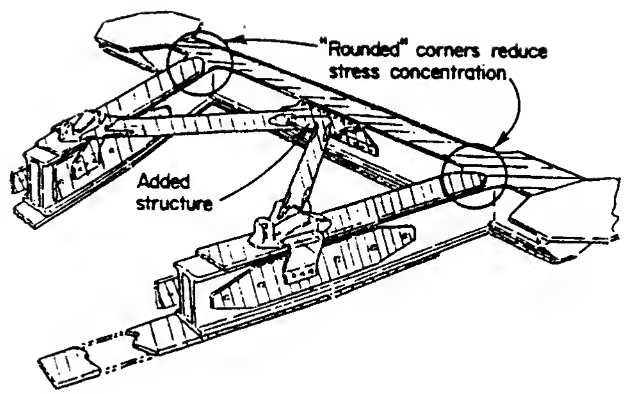


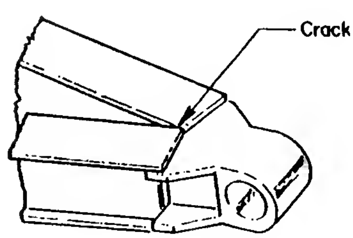
a. Unmodified



b. Modified

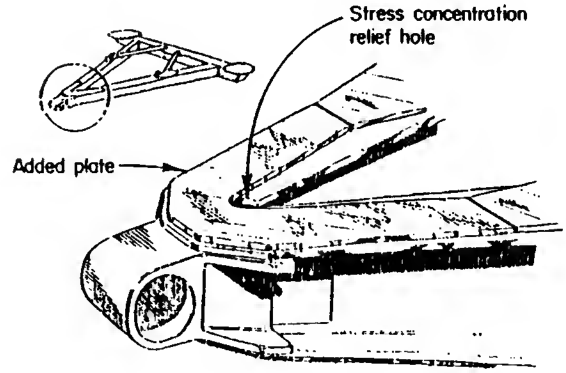
PICTORIAL VIEW OF 96-INCH A-FRAME





a. Unmodified

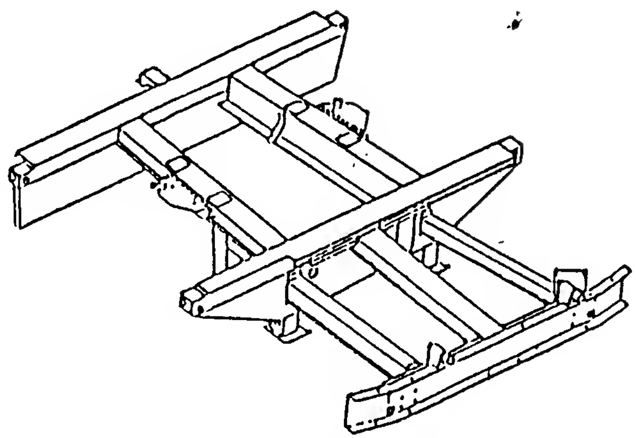
(Centerline weld cracks at the point where the road and curbside beams intersect.)



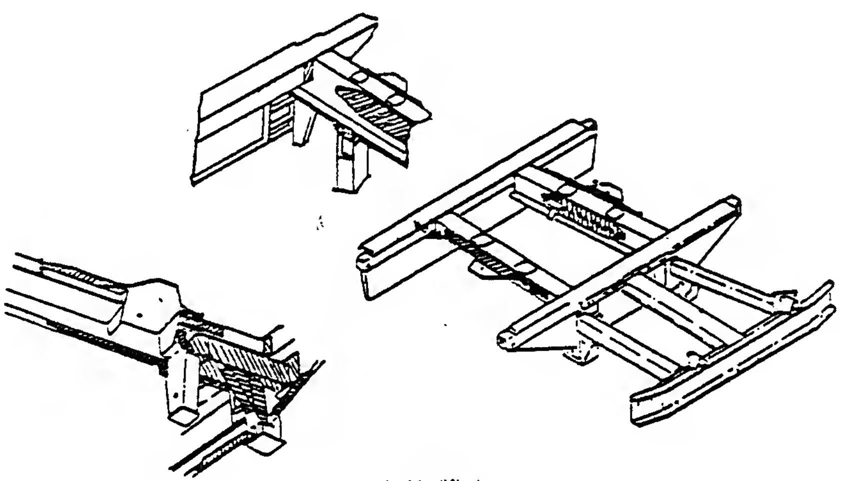
b. Modified

"A" FRAME APEX AND APEX FITTING

Exhibit C-8 Design Modifications

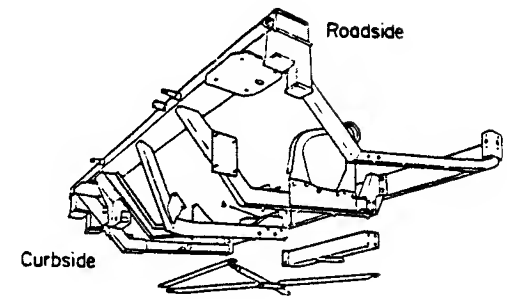


a. Unmodified

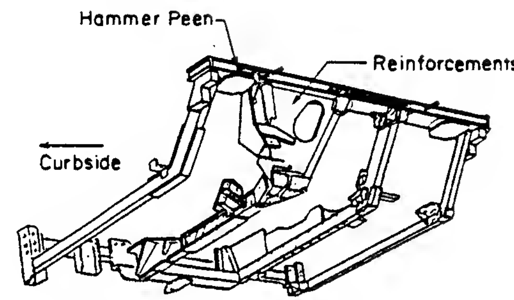


b. Modified

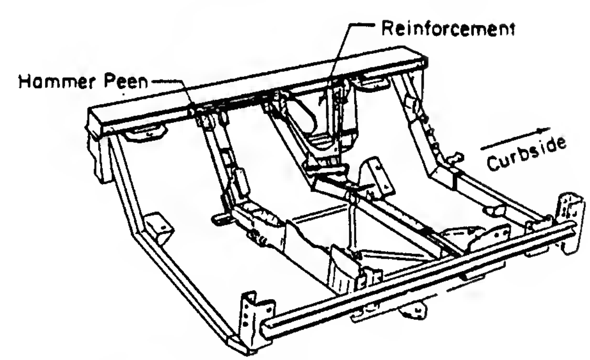
FRONT MECHANICAL ASSEMBLY



a. Unmodified



b. Modified (View Looking Up and Aft)



b. Modified (View Looking Down and Forward)

ENGINE CRADLE

Exhibit C-8 cont.

PART D: NOW WHAT?

UMTA's Role

UMTA has been criticized for not playing more of a role in the testing of the ADBs. The General Accounting Office reported that "UMTA generally does not assume any responsibility for testing buses and does not require any testing to demonstrate that the buses being funded meet the requirements of its specifications."[17] It is ironic that when UMTA did take charge of a bus project -- the Transbus -- from the design phase through testing, it backfired.

It is generally agreed that Transbus is too expensive an endeavor, but a lot was learned about bus technology as a by-product of the project. ADBs are still in production and most of the problems have been ironed out. Foreign manufacturers have entered the market.

Mike Buckel is still at Booz-Allen and he thinks that Transbus could make a comeback some time in the future if the technology catches up. Ed Kravitz is still with Flxible, but the 870 issue is not dead. Grumman sued Rohr industries in 1983 claiming that Rohr knew the designs had some problems. Grumman then sold the Flxible company in July 1983. Exhibit D-1 is an article from the New York Times announcing the sale.

---

[17] The Urban Mass Transportation Administration's Involvement in Bus Specification and Testing (Washington: U.S. General Accounting Office, 1981) p. 15.

Flxible Sale

The General Automotive Corporation, Ann Arbor, Mich., said it had completed the acquisition of the assets of the Grumman Corporation's Flxible bus subsidiary for an undisclosed amount of cash, notes and preferred stock. General Automotive, a privately held corporation, said Flxible has an order backlog of about 600 buses worth more than $100 million at its Delaware, Ohio, plant. The company also said the General Electric Credit Corporation had granted a $45 million line of credit to Flxible. The subsidiary had been losing money for Grumman, mainly as a result of problems with cracked frames in one model of bus.

Exhibit D-1 New York Times Article on Flxible Sale, July 1983.

Washington
Internships for
Students of
Engineering

INSTRUCTOR'S GUIDE FOR A CASE ON

TRANSBUS AND THE ADVANCED DESIGN BUS: THE STRUGGLE FOR AN INNOVATIVE BUS

by

Adlynn Kustin[1]

May 1988

Prepared as part of the 1983 Washington Internships for Students of Engineering (WISE) Program under the supervision of Dr. Barry Hyman[2], 1983 Faculty-Member-in-Residence. Modified and edited by Dr. Hyman. All opinions presented are those of the author and do not in any way represent those of the author's institution, or of other individuals or institutions referred to in the text.

---

[1] Mechanical Engineering Student, Columbia University. Ms. Kustin's participation in WISE was sponsored by the American Society of Mechanical Engineers.

[2] Associate Professor, Mechanical Engineering and Public Affairs, University of Washington.

This case examines the efforts of the United States Department of Transportation to encourage the development of an innovative bus in the 1970s. The ensuing struggle in the evolution of the bus designs makes for an interesting story of an engineering challenge. The story focuses on the battle between what the government wanted and what the manufacturers could or would produce.

As a highlight, the roles of two engineers in the project are included. One works for the research and development firm contracted by DOT, the other for one of the manufacturers. Each played a key part in the development of a bus that would be accessible to the elderly and handicapped, appealing to the eye, comfortable, maintainable and energy efficient.

There are several educational uses for this case; much is deliberately left to the instructor's choice. The case is separated into four main parts allowing the instructor to omit a section to fit the case into a given amount of time or to provide a focus on a particular aspect of the case.

Most upper-division engineering students using this case will have the appropriate technical skills to analyze the bus design problems in some detail. Exhibits C-4, C-5 and C-8 present problems and solutions to structural flaws; Exhibit C-7 provides a good basis for strength of materials problems; and Exhibits A-2, A-5 and A-6 have information that an engineer might consider in overall design options.

Engineering students can also learn from the non-technical aspects of the case. One interesting topic is the way in which industry can influence policy decisions. If no one will produce the bus, all the mandates in the world will not get one into production. Another subject might be anti-trust laws and free competition.

The student who has used the case well should become sensitive to the many political and technological forces which govern the development of an innovative project.

The following are some suggested questions which might be helpful in the classroom on homework or examinations.

PART A: IMPLEMENTATION OF A NEW DESIGN

1. What is the role of the Urban Mass Transportation Association (UMTA)?

2. Why was the schedule presented by UMTA unreasonable?

3. What other industries were involved in innovative technology for the bus and how might their state-of-the-art influence a bus design?

4. Suggest some specific tests for durability and/or safety.

5. Why would GM have been bringing two designs along in parallel?

6. How could the difference in step height become a major problem in boarding a bus in a wheelchair.

7. Why did the DOT allow manufacturers to go into production before a specification was drawn up?

8. In your opinion, was the Houston Consortium exclusionary?

9. Suggest a way in which some continuity of purpose and goals might be achieved over successive administrations.

10. Why might the tandem axle have presented structural problems in the design of the Transbus?

PART B: THE DEBATE

1. Suggest some solution to Grumman's 14 impossibilities.

2. Were the manufacturers correct in their refusal to bid? Why or why not? Cite political, technical and financial reasons.

3. If accessibility was not at issue, why would UMTA make a fuss over the ADB? Was the ADB indeed a Transbus?

4. Was the 22" floor impractical?

5. Why was the technology advancement compressed into a few years?

PART C: THE ADB'S

1. What possible causes were there for engine cradle cracks?

2. Why might GM not have realized that the combined air conditioner/radiator could cause problems? Suggest an alternative to the 35 hp fan for cooling.

3. How can the media affect technological decisions?

4. Suggest your own procedure for fixing the 870's structural problems.

5. How would you set up a laboratory to analyze and fix the problems with the 870?

6. Using what you have learned in solid mechanics, explain why there were fatigue cracks and buckling.

7. What kinds of factors would you suppose acted on the buses when they were in service and what caused those stresses? (See Exhibit C-3)

8. Explain in your own words why the material properties of the HSLA steel were misrepresented.

9. Why wasn't the same rigorous testing done before the ADB's were in service, before millions of dollars were invested?

PART D: NOW WHAT?

1. Was the Transbus project worth the $28 million the government spent on it?

2. What lessons were learned from the Transbus/ADB conflict?